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BY

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WITH SIX ILLUSTRATIONS

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PREFACE

I HAVE often thought that the Science one learns in School, and sometimes even in College, is shorn of some of its " humanity " through our ignorance of the lives and work of the pioneer Scientists, and that so one misses a great source of interest and inspiration. For I do not think one is overstating the case when one calls inspiring the long patient search for truth, and the willingness to endure material hardship, and what is worse to a sensitive mind, stupid misunderstanding and storms of criticism, often from those who had been counted as friends.

And as one reads the lives of the great men of Science, one realises that they one and all had to endure hardness, to exercise unfailing courage, patience, perseverance, and that most difficult form of honesty, honesty of thought—and further, one learns the depth of devotion to humanity which underlay the work of men like Pasteur, Lister and Galton, and the debt of gratitude which we one and all owe to them for the benefits which they have given to us, and which we now so calmly take for granted.

It is always well to keep green the memories of benefactors—and it is well to remember that Science has a very human side—and so I have tried here to sketch the lives and work of six famous Scientists of the nineteenth century, that century which produced so many outstanding personalities in Art, Literature, Philanthropy, Politics, as well as in Science.

I am indebted for information to the following books and papers :—Sir R. J. Godlee's *Life of Lord Lister* (Macmillan, 1917), the publications of the Research Defence Society, Professor Frankland's "Pasteur Memorial Lecture," published in the Journal of the Chemical Society (vols. 71 and 72), "*A. R. Wallace. Letters and Reminiscences*" by J. Marchant, Punnett's "*Mendelism,*" "*The Life of Charles Darwin*" by F. Darwin, and to various other books and papers, which, as far as possible, are referred to in the text.

M.A.

March, 1923.

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LOUIS PASTEUR

1822-1895

IT is perhaps a rather appropriate time just now for refreshing one's memory of Pasteur's work.

Always, he stands on a pinnacle of scientific eminence whose height has been reached by only a few other men—and the War has enormously emphasized the benefits which he has bestowed on humanity.

Pasteur is, I think, unique amongst scientists in the versatility of his mind, and the consequent scope of his work, and the practical value to humanity of that work. Pure Science often shows very little practical result—at least for a long time; it has a tendency, in the opinion of the "man in the street" at any rate, to flower seldom, like the Yucca of our gardens, and it is often looked on askance by the General Public for this reason. In Pasteur's case, however, we have an exception to this state of things, for the practical results of his work had, almost at once, enormous effects on chemistry, on commerce, on methods of treating disease in animals, including man and the lower animals, on sanitation and public health; and he was fortunate in that he lived to receive the

admiration and thanks of almost the whole world—a recognition which in many cases has only arrived in time to be recorded on a tombstone. He provides, I think, the outstanding example of a scientist whose work could be practically applied to the advancement of human life—and his personality is curiously attractive in its warm-heartedness and humanity. He was very markedly a human being, not a chilly abstraction.

Pasteur was born in quite humble circumstances, at Dôle in the Jura district of France, in 1822. For three generations his family had been tanners in this district. His great-grandfather was the first freeman in the family, having bought himself out of serfdom. Pasteur's father as a young man had been one of Napoleon's conscripts and had won the Cross of the Legion of Honour on the field of battle, for valour and fidelity. Thus the son was fortunate in possessing forbears of character and strength. There is much evidence of the influence of the father on the son; Pasteur showing time after time the strength of his devotion to France. He was perhaps even more of a patriot than of a scientist; *e.g.* in 1848, when Europe was politically greatly upheaved, Pasteur enrolled himself in the National Guard and seeing one day in the Place du Panthéon, a sort of altar labelled "autel de la patrie," promptly placed on it all his worldly wealth—150 francs. Again, in 1870 he was returning from Germany to France, and at Strasburg, heard that France was on the verge of war with Germany, whereupon he hurried to Paris and was exceedingly disappointed when the military authorities refused to enrol him in the National Guard—on the score that a half-paralysed man was useless in the army. (He had had a paralytic

stroke two years before, in 1868, and never shook off the physical effects, though after two years he was able to continue his mental work as well as ever.) His gratitude to, and admiration for his father are shown in the dedication of his most famous book (*Études sur la Bière*) to his father.

However, to return to his boyhood—when he was two years old the family moved from Dôle to Arbois, where his father bought a small tannery, and here Pasteur was sent to school at the Communal College, where at first he showed no interest whatever in books or study but devoted his attention to fishing and to sketching his companions. However, directly he grasped the fact that his education was a great drain on the family funds, he set-to in earnest at school and soon developed the passion for work which marked the whole of the rest of his life.

The College at Arbois did not teach philosophy, and so, after a time, Pasteur went on to Besançon, a bigger place, with better educational provision. Here he graduated in Science and Arts and was given a post on the College Staff.

He was already much interested in Chemistry—too much so for the professor of that subject at Besançon, whom Pasteur used to embarrass with unanswerable questions. The professor in question disapproved of saying "I don't know"—and used to try to keep Pasteur "in his place" by telling him that questions were to be asked by the Teacher of the Scholar, and not *vice versa*. One rather sympathises with both in this dilemma.

In 1842, *i.e.*, when he was twenty, he went in for the entrance examination to the great École Normale in Paris and came out fourteenth on the list, whereupon he refused to enter, being so

disappointed at not getting a higher place. He took the examination again in the following year and was fourth on the list, which apparently more or less satisfied him.

Now he was able to attend lectures by really great chemists, such as Balard, the discoverer of bromine, and Dumas, and under their influence he devoted himself entirely to chemistry and was specially led to the study of crystals and their action on light passing through them. All crystals, except those of the cubic system, polarise light as it passes through them, *i.e.*, cause the vibrations of the ether, which produce light, to occur in one direction only instead of in all directions at right angles to that of the ray. This fact had been discovered in 1808, *i.e.*, thirty-four years before Pasteur was attracted to the subject. Further, it was known that certain liquids, *e.g.*, tartaric acid, sugar solution, camphor solution, affected polarised light if it were passed through them,—altering the plane of the vibrations. Now, just at this time, Pasteur set to work to study the crystalline form of tartaric acid and the tartrates, *i.e.*, compounds, or "salts," derived from tartaric acid—with the result that he noticed little facets on the crystals which had never been observed before, and these facets were similarly placed in *all* the salts (and he prepared nineteen different tartrates). Then he tried the effect of dissolving the crystals and passing polarised light through the solutions and found that *all* rotated the plane of polarisation in the same way.

He inferred from this that the newly discovered facets on the crystals had something to do with the fact that all the solutions affected light similarly. Now a substance called *racemic acid* is known,

which resembles tartaric acid in chemical composition but has a different crystalline form and *no effect on light, i.e.*, it is said to be "optically inactive." Pasteur next examined its crystals and found that they had none of the facets which he had discovered on tartaric acid. This, of course, strengthened his idea that the crystalline form was connected with the optical properties of substances. However, when he came to examine one of the racemates (sodium ammonium racemate) he found that its crystals were of *two patterns*—mixed, one pattern having facets all turned to the right and one having facets all turned to the left. He carefully separated these into two heaps, dissolved each heap in water, and tried the effect of the two solutions on polarised light, with the result that the right-handed crystals turned the plane of polarisation to the right and the left-handed crystals turned it to the left. Pasteur was so overcome with excitement at this that he rushed from the laboratory, and, meeting a friend, embraced him, told him of the discovery, and added, "I am so happy about it that I am shaking to such an extent that I cannot again get my eye to look through the polariscope." He submitted his results to the greatest authority on the subject, Biot, who subjected him to a most searching examination, at which Pasteur had to repeat his experiments under the eye of the master. However, everything "worked," and at the end Biot, much moved, seized Pasteur's hand, exclaiming, "My dear boy, I have loved the Sciences so much, all my life, that this makes my heart leap." The meaning of the discovery was that racemic acid is composite, consisting of two kinds of tartaric acid, with equal and opposite effects on light. From this Pasteur

concluded that the difference in the two kinds of tartaric acid must lie in a difference in the arrangement of the atoms in the molecules—and so he created a new branch of Science (Stereo-Chemistry, or chemistry in space, or Solid Chemistry), which has attracted many other workers and led to most valuable and important practical results in the discovery of new compounds, many of which are now used medically and are of almost incalculable value (*e.g.*, Professor Ehrlich's "Salvarsan," used for a widespread contagious disease, also certain antiseptics).

Pasteur continued these experiments in pure chemistry from 1844 to 1860, *i.e.*, for sixteen years, and in the course of them hit, by chance—only there was genius to seize the chance—on a new way of separating the optically inactive racemic acid into two optically active tartaric acids, and this method had such interesting effects on his later work that one must describe it very briefly here. He noticed one hot day in summer that a tartrate solution in his laboratory had begun to get turbid and to ferment. Instead of flinging it away as spoilt, as most people would have done, it suggested a new idea to him :—Would fermentation have any effect on racemic acid? To solve this problem, he set up fermentation in a racemate and found that the inactive liquid gradually became optically active in consequence, *i.e.*, fermentation separated out the two active constituents, destroyed one and left the other, and this discovery was one of the factors which led on to his remaikable work on *Fermentation*, which has been of enormous commercial value.

At this point one may say a word about his private affairs. In 1848, at the age of twenty-six,

he became Deputy-Professor of Chemistry in the University of Strasburg, and here he met his future wife, who was the daughter of the rector of the Strasburg Academy. They were married in 1850, and it seems that Pasteur was so buried in his work on the wedding day that he entirely forgot the ceremony and had to be fetched by a friend. The marriage, however, was extremely happy, and the wife seems to have been an important factor in her husband's work. The following is a description of the ménage written by one of Pasteur's fellow-workers :—"The career of Pasteur cannot be properly understood without a knowledge of his family, and above all of Mme. Pasteur. From the first days of their united life, Mme. Pasteur realised what manner of man she had married, and endeavoured to protect him from the difficulties of life, taking upon herself the cares of the house, so that he might keep his mind perfectly free for his researches. Mme. Pasteur loved her husband to the extent of understanding his labours. In the evening she wrote to his dictation, asking for explanations, for she took a living interest in the hemihedral facets and in the attenuated viruses. Moreover, she saw well that ideas become clearer through exposition, and that nothing is more conducive to the suggestion of new experiments than the description of those which one has just carried out. Indeed, Mme. Pasteur was not only a perfect companion to Pasteur, she was his best assistant." Clearly, Pasteur was fortunate in his wife. One wonders how much of our gratitude to him is really due to her.

We come now to a new departure in Pasteur's scientific work, brought about by the two facts that in 1854, when he was thirty-two, he was appointed

the first Dean of the Faculty of Science at Lille, and that he always felt an unfailing interest in the humanity around him. Pasteur never seems to have lost himself, so to speak, in abstract science. His interest in his fellows and his country tied him to earth, in a good sense, and so we find him at Lille, at once trying to connect the work of his Science Department with the chief local industry, viz., the manufacture of alcohol from beet and grain, by giving lectures on *Fermentation*. At this time people did not know that fermentation was due to plant-life developing in the fermenting liquid, as we do. They thought it was a purely chemical process of decomposition (or decay). Pasteur, however, proved that when the yeast plants were put into sugar solutions they grew and multiplied, meanwhile converting the sugar into alcohol and carbon dioxide. Further, he proved that a different type of plant-life (the lactic bacilli) would grow in sugar-solution and convert it into lactic acid, and so he was led on to a great series of researches on fermentation, in the midst of which, in 1857, he was appointed Director of Science at the École Normale in Paris. This, though an advancement, was not an unmixed blessing, because in Paris he had no laboratory, and the Government said it could not afford one, so that he had to make one, at his own expense, in a garret of the École Normale, where he went on studying fermentation, discovering amongst other things that some bacilli did not like fresh air, whilst others did, and so dividing them into the two groups with which we are familiar enough to-day—*aerobes and anaerobes.*

Until Pasteur made this discovery it was supposed that all living things needed oxygen ; now we know that certain bacteria, e.g., those of

tetanus (lock-jaw) *can only* live in absence of air, whilst many *can* develop without it. This fact is of great importance in Sewage Disposal, at least in all methods other than that of running sewage direct into a river or the sea, and obviously the sea is not a possible receptacle for an inland town, and more and more it is being made illegal to contaminate rivers with untreated sewage. Hence more and more installations are being set up for dealing with sewage bacteriologically, so as to render it harmless before it is run into the river. The first process in such a system is that of the *Septic Tank*, in which air is excluded, and consequently the *anaerobic* bacteria get their chance. They are always present, naturally, in sewage, and under suitable conditions such as the septic tank provides, they multiply and meanwhile decompose the organic matter in the sewage, converting the solids into liquid. Then the second stage of treatment begins: the sewage is exposed to light and air, which gives the *aerobic* bacteria their chance. They also are always present, naturally, in sewage, and they continue the work of purification till the sewage is as safe as ordinary water and can be turned into any stream without hurting that stream as a drinking water supply. Belief in the existence of *life without air* was by no means accepted easily by Pasteur's contemporaries; in fact there was a storm of unbelief, criticism and opposition—the usual storm which greets all new ideas—but in spite of the commotion Pasteur firmly adhered to his statements, and he lived to see the dying down of the storm and the acceptance of his views.

Now we come to an interesting by-path in Pasteur's work. In 1847, two years after his

going to Paris, his daughter caught typhoid fever and died of it, and he seems to have felt this loss very deeply. Family ties were very strong for him, and he was intensely distressed if anyone or anything had to bear pain, e.g., he always insisted when operations on animals were done in his laboratory, that the animal was anæsthetised. Émile Roux said that Pasteur's agitation at witnessing the slightest exhibition of pain would have been ludicrous if, in so great a man, it had not been touching. A few months afteı his daughter's death Pasteur wrote to a friend :—" I am pursuing as best I can these studies on fermentation, which are of great interest, connected as they are with the impenetrable mystery of life and death. I am hoping to make a decisive advance very soon, by solving the famous question of *spontaneous generation*."

* Now, the idea that life could originate casually and spontaneously from dead matter was very ancient, e.g. :—

(1) *Aristotle* says that " every dry body becoming moist, and every moist body becoming dry engenders animals."

(2) *Virgil* says that " bees originate in the decaying carcase of a young bull."

(3) *Van Helmont* gives a prescription for creating mice, as follows :—" Squeeze some soiled linen into the mouth of a vessel containing some grains of wheat ; this will cause the wheat to turn into mice in about twenty-one days, the mice so generated being adult and of both sexes."

One cannot help wondering at the curious credulity of the public opinion of those days, and at the

* See Journal of the Chemical Society, July, 1897, Pasteur Memorial Lecture, by Frankland.

strange absence of experimental verification of these fascinating statements. However, experiment began at last, when an Irish priest, Father Needham, in 1745, tried heating sealed vessels containing substances liable to decay, with the result that plenty of microscopic living plants appeared in them. He assumed that the preliminary heating had been enough to destroy all life in the vessels and hence that the living bacteria which subsequently appeared had been "spontaneously generated" from dead matter.

In "1763," however, an Italian priest, the Abbé Spallanzani, repeated the experiments, but heated the vessels more thoroughly, with the result that *no* bacteria appeared subsequently. Hence he came to the conclusion that "spontaneous generation" was impossible.

Subsequent investigators got doubtful results, and in 1860 the French Acadamy offered a prize for the solution of the problem whether spontaneous generation was or was not a fact, and Pasteur entered for the competition, and settled the matter once and for all in the negative, proving that if a substance be sufficiently heated to destroy all life and if the air in contact with it be filtered, so that it is free of germs, then the substance does *not* alter, i.e., bacteria do *not* develop in it. As usual, his opponents said they had obtained opposite results, so Pasteur asked for arbitration, and the Academy appointed a Commission, before which Pasteur and his adversaries were to repeat their experiments. On the appointed day, Pasteur appeared loaded with apparatus. His opponents, however, had none; they said the weather was unpropitious and they would like to wait. The Commission very reasonably refused; Pasteur

did his experiments successfully and won the prize. In the course of these experiments Pasteur found that some germs are very difficult to destroy by heat; e.g., milk developed bacteria even after several minutes' boiling, but after raising the temperature 10° C. *above boiling point*, he found that no bacteria were left alive. This work on spontaneous generation was of great value because it stimulated other scientists to study the habits of germs, and much of our modern knowledge of these invisible but very active plants sprang from Pasteur's discoveries.

Pasteur now returned to his work on fermentation, and, true to his determination to apply Science to industry and to the welfare of humanity, we find him explaining to the vinegar-makers of Orléans exactly how the bacteria (mycodermæ aceti) which convert wine into vinegar ought to be treated in order to make the maximum amount of vinegar in the shortest time, and from this he went on to study the manufacture of wine, and hence passed to beer, silk-worm disease, and finally to the diseases of the higher animals, including man.

With regard to wine, it occurred to him that the souring of wine was probably due to bacterial action, and he proved that this was so, and further, worked out preventive measures. Thus he tried adding antiseptics to the wine, but the result was unsatisfactory, so he proceeded to try heat and proved that a comparatively low temperature was enough to kill *harmful* bacteria, though not all—i.e., he used the method now generally known as "pasteurisation," a method which has proved of the greatest value in preserving other kinds of food besides wine, e.g., milk and cream, and

which will probably come to be even more used than at present, for people are beginning to realise that the wholesale use of preservatives in our food is likely to lead to serious digestive troubles.

This brings us on to 1870, when France and Germany were plunged into War, and Pasteur, ever intensely a lover of France, was filled with sorrow and anxiety, and with loathing of Germany, e.g., he wrote to the University of Bonn, which had bestowed on him the degree of Doctor of Medicine, asking that his name should be removed from the Faculty of the University, and returning his diploma, of which he speaks thus :—"To-day, the sight of this parchment is odious to me, and I feel offended at seeing my name . . . placed under the patronage of a name doomed henceforward to execration by my country, that of Rex Guilelmus . . . ." Having offered himself as a soldier and been refused on the score of physical incapacity, this unconquerable man turned to the sword of Science, and took up the study of brewing, in order to discover a method whereby France might produce beer as good as that manufactured in Germany. He imparted his discoveries to the English brewers as well as to the French, with the rather illuminating remark, "We must make some friends for our beloved France." In 1876 this work was published in a book called "Études sur la Bière," which has been translated into English and is the best known of all Pasteur's books in England, where it has been of tremendous value in the brewing industry. Huxley once said that Pasteur's work on fermentation alone saved France more than enough to pay the indemnity of the Franco-German War.

However, Pasteur's work on fermentation did

not stop short here; it had far more important effects on medicine, surgery, and public health, for it was the starting-point for Lord Lister's work on *inflammation of wounds*, which in those days caused endless trouble after operations, often making amputation necessary, and frequently even this was not enough to save the patient's life. About 33% of deaths from major operations occurred in pre-Listerian days, with the result that surgeons were unwilling to operate except as a last and desperate resort.

Now Pasteur's discovery that fermentation was due to bacteria set Lister wondering whether inflammation was not also a type of fermentation due to bacteria getting into the wound. And as the result of a series of brilliant researches he proved that this was so, and that, if only germs were excluded from wounds, inflammation was averted. Thus the foundation of Modern Surgery was laid. It is tragic that Lister's discoveries, made in 1868–69, just before the outbreak of the Franco-Prussian War in 1870–71, were not applied in that War. It has been said that, if they had been used on behalf of France, she might have proved the winner instead of the loser. At any rate, thousands of lives would have been saved. Pasteur's realisation of the tragedy of ignorance in high places is shown by his remark, "We are paying the penalty of fifty years' forgetfulness of Science and of its conditions of development."

The *antiseptic* method in surgery has led on to the *aseptic* method of to-day, where the ideal is to keep the patient's skin free from germs, so that the living tissues need not be soaked in carbolic, which tends to destroy the tissue as well as the germ. Hence, though the instruments

and the doctor's hands and everything else are rigorously disinfected, the *wound* is *not* thus treated, unless it be an old wound, already infected. The enormous value of this work is shown by the fact that the death-rate to-day in major operations has fallen to about 1%.

To return to Pasteur—the achievement by which he is best known to the man in the street, viz., his work on disease, was led up to by an investigation into which he was almost forced by the French Government. This was the result of a mysterious epidemic of silkworm diseases which for fifteen or sixteen years had been devastating the silk-industry in the South of France. Now, the keeping of silkworms was one of the chief home-industries of the peasantry of that part of France. Practically every family set aside the best room in the house for the rearing and tending of silkworms; the women got up even during the night to supply the worms with fresh mulberry leaves and to see that the temperature of the room was just right; and in that region the common greeting on meeting a friend is said to be not "How do you do?" but "How are your silkworms doing?"

Until 1849 the industry had flourished consistently, but in 1849 the moths were attacked by disease. It was thought at first that the eggs were at fault, and fresh ones were brought from other countries, and for one season this cured the disease; but it reappeared in the first generation of descendants of these imported worms, and so the inhabitants were driven to import fresh eggs each year. Soon, however, the disease spread to neighbouring countries, until Japan was the only silk-producing country free from the disease. This reduced the silk-growers to despair, thousands

of families were faced with ruin, and things were so serious that in 1865 the Government asked Pasteur to investigate the disease. At first he refused, on the ground that he was a chemist and not a naturalist and had never touched a silkworm in his life; but he pleaded ignorance in vain. "So much the better," replied M. Dumas, who bore the message from the Government, "you will only have the ideas which come to you from your own observations." This, coupled with his sympathy for the people of the devastated region, overcame his reluctance, and he set out for Alais, a town in the silk district.

Now, earlier observers had noted microscopic grains or "corpuscles" in the bodies of the diseased worms, but nobody had succeeded in finding a remedy, until Pasteur suggested collecting the eggs laid by each moth separately and only keeping those derived from healthy parents. The only way in which this could be done was by use of the microscope, and Pasteur realised that this instrument would be a strange and terrifying thing to the peasants, so he tried to reassure them by telling them that his little girl of eight years old was quite at home with it. In addition, he directed the silkworm rearers' attention to the need of avoiding over-crowding, uncleanliness, over-heating, and unhealthy conditions generally, since these weakened the insects and made them more liable to the disease.

This treatment, though it was not at once adopted, was very successful in decreasing the epidemic, but it has never *completely* eliminated the disease, apparently because the silkworm is not the only insect which harbours the parasitic bacteria which cause silkworm disease. What it

has achieved, however, is the keeping of the disease well in check and the consequent saving of millions of money. It has been estimated that before Pasteur came to the rescue France had lost forty million francs through silkworm disease. An even more important result of this work was that it led Pasteur on to study the infectious diseases of the higher animals, including Man.

It was during his work on the silkworm that Pasteur suffered from a stroke, the physical effects of which he never shook off. It has been attributed to overwork on the silk-problem. Providentially, however, his mind was *not* injured, and in 1877, at the age of fifty-five, he began to study the cattle-disease named *Anthrax*. It had already been suggested that this was due to a germ, and Pasteur finally proved the truth of this theory and, further, worked out preventive treatment. He cultivated the anthrax bacillus in such a way that it became only mildly poisonous and proved that these attenuated germs introduced into an animal's blood gave rise to only slight symptoms of anthrax and protected the animal from taking the deadly form, much in the same way as vaccination prevents smallpox. This protective treatment has safeguarded millions of sheep and cattle from the disease. Reports from France and Hungary show that on many farms the death-rate from anthrax has fallen from 10% to 1% amongst sheep and from 5% to less than 1% among cattle. The treatment was first used in 1881. In England, cattle do not suffer much from it, and isolation and disinfection are enough to keep the disease within bounds, but in other countries, where often the soil is saturated with the disease, it is a most serious problem, and it is here that the protective treatment is used.

It is estimated to have saved French farmers 280,000 francs in ten years.

Pasteur went on to study many other diseases, and in connection with each "he left either a method or a clue;" *e.g.*, *Swine erysipelas* is a disease which in some countries kills a large number of pigs—and he discovered an inoculation treatment for this which has cured or prevented innumerable cases (*e.g.*, in Germany and Hungary). Other diseases which have become manageable as a result of Pasteur's work are *Rinderpest*, which used to be rampant in cattle in this country and appeared in 1897 in South Africa; *Pleuro-pneumonia*, which was stamped out of this country in 1898; *Texas Cattle Fever*, *Horse Sickness*, *Malignant Jaundice* in dogs, *Glanders*, *Distemper*, *Tubercle* in cattle, *Lock-jaw* (Tetanus) in horses—and it must be remembered that the methods which have saved millions of animals were discovered by experiments *on* animals. One should bear this in mind when one comes up against the anti-vivisectionist.

And this brings us to the next stage of Pasteur's work—that on human diseases. Overcoming his dislike of seeing suffering, he visited the hospitals, collecting infectious matter from patients, examining it microscopically and identifying the germs associated with various diseases, *e.g.*, at this time the Maternity Hospitals were devastated by *puerperal fever* in every country, and an appalling number of women died from the disease. Pasteur discovered its germ, and an interesting little episode is recorded by M. Roux in connection with the discovery. "One day, at a discussion on puerperal fever which was taking place at the Academy of Medicine, while one of the most distinguished authorities was eloquently descanting on the causes

of epidemics of this disease at Maternity Hospitals, he was suddenly interrupted by Pasteur as follows :—' It is nothing of all that which causes the epidemic ; it is the doctor and his belongings which carry the germ from the diseased to the healthy woman.' And when the speaker replied (with the superiority which we can all imagine) that he was afraid they would never discover that microbe, Pasteur rushed to the blackboard and drew the germ, saying, ' Stop, here is its picture.' " Nowadays, thanks to Pasteur and Lister, epidemics of this disease in Maternity Hospitals are unknown.

Various little incidents illustrate Pasteur's determination to stick to essentials and to waste no time on unimportant details of classification, etc. Thus, a learned morphologist one day arrived at the laboratory with the information that a germ which Pasteur has described as a *micrococcus* was really a *bacillus* (the difference is merely one of shape). Pasteur replied shortly, " If you want to know, it's all the same to me." On the other hand, he had the true scientist's instinct for the detail which *is* important, and unlimited patience in experimenting and in awaiting results. This is illustrated by the story of how he discovered the method of making *vaccines, i.e., weakened* germs, which can be inoculated in measured quantities into human beings as a cure or preventive of the disease caused by the ordinary unweakened germ.

He had gone away from his laboratory for a holiday, in 1879, whilst working at fowl-cholera, and on his return found all his cultivations of the germs dead or dying. He proceeded to inoculate various birds with these dead or dying germs and found that the birds showed signs of illness but recovered. The idea then occurred to him of

inoculating them with a fresh lot of virulent germs of chicken-cholera, and he was amazed at the result, viz., that the birds still resisted the disease, though others, which had *not* been previously dosed with the exhausted germs, died. So he arrived at the method of *attenuating* germs, *i.e.*, of cultivating them so that they were weakened, and also at the fact that such germs inoculated into a healthy animal produced a mild type of illness which protected the animal from attack by the virulent form of the disease.

The first human disease to which Pasteur applied *inoculation* was *Hydrophobia or Rabies*, the horrible illness produced by the bite of a " mad " dog. To give one some idea of its horrors one need only read such descriptions as the following, of a child of five, admitted to a French hospital. " The unfortunate little patient presented all the characteristics of hydrophobia : spasms, restlessness, shudders at the least breath of air, an ardent thirst, accompanied with an absolute impossibility of swallowing convulsive movements, fits of furious rage. The child died after twenty-four hours of horrible suffering—suffocated by the mucus which filled the mouth."* As a matter of fact, its germ has never been found, but it was known that the part of the body affected in hydrophobia was the nervous tissue, and Pasteur tried taking some of the nervous tissue of an animal which had died of the disease and attenuating it, which he found could be done by exposing the spinal cord of rabid rabbits to dry air, which weakened it until after fourteen days it was harmless. The attenuated spinal cord intorduced into dogs rendered them immune to hydrophobia, but the treatment was not tried on human

* " The Life of Pasteur," by René Vallery-Radot.

beings till 1885, when a boy, Joseph Meister, was brought to Paris for treatment from a little place in Alsace. He had been bitten by a mad dog two days before. Now, human beings do not as a rule develop hydrophobia for a month or so after being bitten, and Pasteur, being as usual extremely anxious to ward off suffering, undertook the treatment of the boy by inoculations, which were continued for ten days. Meanwhile the boy was hardly ill at all and played about the laboratory very happily, though Pasteur was devoured by fears and anxiety about the results. However, the boy was absolutely cured, and two months later a shepherd, who had been bitten by a mad dog, was similarly cured, and three months later three hundred and fifty cases had been treated, with only one death. By 1899, more than twenty-three thousand people had undergone the treatment, and the number to-day must be larger still. The deaths amongst these were less than $\frac{1}{2}\%$, and there is no doubt that many of the rest were saved from a terrible death by Pasteur's work.

But, though this was the last of Pasteur's great discoveries, its results were by no means confined to the cure of hydrophobia, for the fame of his success stirred up other scientists to try similar methods of cure for other diseases, and in the ten years between 1880 and 1890 they discovered the germs of consumption, diphtheria, typhoid, lockjaw, cholera, and Malta fever.

In 1893 the antitoxin which cures diphtheria was discovered, and also the protective treatment for cholera. Before the discovery of the antitoxin 30.4% of diphtheria patients died ; now 8.3% die. In 1894–5 the germs of plague and of the tsetse-fly disease in animals were found. In 1896–7 the

protective inoculation treatments for typhoid and plague were discovered—with the result that in the Great War there was extraordinarily little typhoid in our Army compared with the amount of the disease which had occurred in earlier campaigns, such as the Boer War. " In India, during 1913, 93% of the British garrison were inoculated, and the deaths from typhoid fell from the usual 300–600 to only 20."

In 1898–1900 it was proved that malaria and yellow fever were conveyed by mosquitoes. Now malaria each year kills millions of men and weakens millions more. It was rampant in England, under the name of ague, till, comparatively recently, it was banished by draining the malarial districts. Now we know the cause of the disease we can fight it in two ways—by destroying the breeding-places of the mosquito and by protecting man from the bites of the mosquito. Thus, every puddle of standing water, every pond, etc., should be drained or oiled, and all cisterns and wells should be kept closed in a malarial district, for the mosquito lays its eggs in water. Windows and doors must have wire-gauze shutters. Beds must be protected by mosquito nets. Finally, quinine is invaluable as a preventative and cure. It was this knowledge that enabled the Americans to construct the Panama Canal, after the French had failed hopelessly with enormous loss of life and money owing to the ravages of malaria and yellow fever. President Taft, in 1911, said : " Colonel Gorgas changed a pest-ridden zone into a district as free from disease as any of the States of the South. He stamped out yellow fever, so that for more than four years there has not been a single case on the isthmus ; and he reduced the malignancy and extent of malaria on

the isthmus to such a point that the percentage of deaths in the foreign population in the zone is considerably less than in our large cities. He has made the zone a pleasant and healthful place to live in. Thus the great work of construction goes on without thought now of the dangers which made French success impossible."

In 1903–5 Bruce showed that sleeping-sickness, which devastates Central Africa, was conveyed by a species of tsetse-fly. In 1905 in Uganda it caused 8,003 deaths. In 1910 the number was reduced to 1,546.

It is impossible even to catalogue the list of medical discoveries which have sprung from Pasteur's work—and especially since the Great War, which forced us to deal with many hitherto little-known diseases and conditions and so to greatly increase our knowledge of them. For example, at the beginning of the War tetanus (lock-jaw) was tremendously common amongst our wounded because the soil of Belgium and Northern France is full of the germs of the disease; hence arose the custom of giving every wounded man a dose of anti-tetanic serum, which reduced the number of cases of tetanus to a tiny proportion.

As an expression of world-gratitude, the Pasteur Institute was built in Paris with subscriptions which came from all parts of the world. It was opened in 1888, and was the joy of Pasteur's few remaining years.

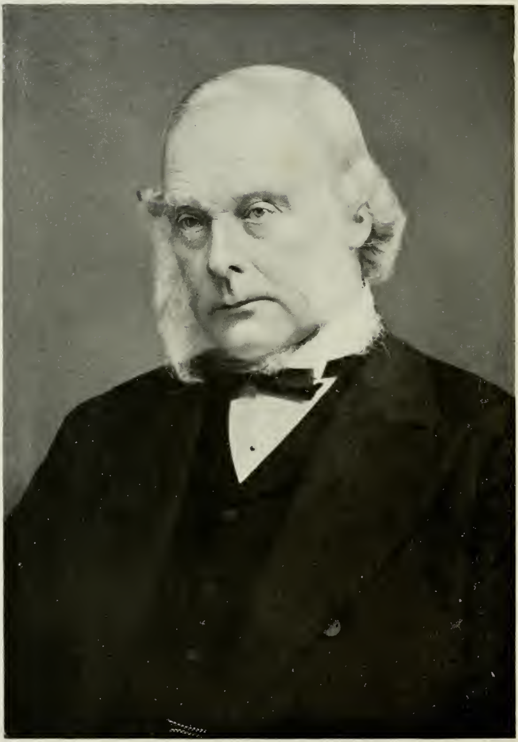
It has been well said that Pasteur "brought the facts of disease and death from the realm of the supernatural and miraculous into the realm of the natural. Disease and death were the great mysteries, where the occult held sway. The malign and mysterious influence of the moon caused

lunacy ; there was the evil eye with its morbific powers ; in fever and in epilepsy the body was possessed by demons ; tuberculosis was the King's Evil, to be cured by the " Sovereign touch." Far more than all other men, Pasteur abolished for ever these superstitions."

And to the end he retained his infinitely attractive love for humanity. " As an old man it was a touching sight to see him amongst the sufferers under treatment at the Institute Pasteur, patting the little children on the head, heartening up the timid and giving sous to the brave, infinitely tender to the frightened mothers."*

Pasteur died in 1895, at the age of seventy-three, and was buried in the Institute.

* Shipley's "Pearls and Parasites."



JOSEPH LISTER
1827-1912

JOSEPH LISTER

1827–1912

LORD LISTER is another of the scientific giants who have been, like Pasteur, benefactors to the whole world, to such an extent that one must know at least the outline of their work and achievements if one is to count oneself tolerably educated—and not basely ungrateful for the favours one has received. And, because Lister's work was so largely the outcome of Pasteur's, it is right to consider it here, immediately following the sketch of Pasteur's life. Pasteur himself refers with special pride to the letter which Lister wrote to him in 1874, ascribing his discoveries in antiseptic surgery to Pasteur's work on fermentation, and this letter was the beginning of a life-long friendship between the two men.

To anyone who realises the importance of heredity in the development of every human being, it is always interesting to know something of the parentage and ancestry of a great man. The Lister family came from Yorkshire, near Bingley, where, at the end of the sixteenth century, there were a good many of them successfully occupied in various trades. In 1705, Thomas Lister, a maltster and farmer, married Hannah Lister, daughter of a yeoman, and both joined the Quakers, and the family mostly remained Quakers till quite recently. Their eldest son, Joseph, became a tobacconist in London, and his youngest son, John, was Lord

Lister's grandfather. John was a watchmaker at first but later on took over his father's business and later still became a wine merchant. He was evidently an adaptable person and of a tough constitution, for he lived to be ninety-eight. He had two daughters and one son, Joseph Jackson Lister, who was a remarkably intelligent and interesting man and the father of Lord Lister.

Joseph Jackson Lister was sent to Quaker schools, where he received a good education, the Quakers having always been famous for their schools, as they are to-day. His father backed up the school nobly in its efforts to impart learning to his son, as is illustrated in the following letter which he wrote to Joseph when the latter was aged ten. It might serve as a model for the modern parent in many respects, it seems to me.

"21st of 3rd month, 1796.

"Dear Joseph,

"As I often think of thee with desires that thou may grow up a sober industrious lad, so am also desirous that thou shouldest see a little of what is publishing for the instruction and benefit of the youth of the present Generation and adapted to the capacities and employments of many of them, have therefore sent thee nine Books for the purpose, and I greatly desire that thy principal care may be to discharge thy duty to thy teachers, and to keep a conscience void of Offence to thy Creator from Whose bounty we are supplied with every favour that we enjoy. But on enquiring after thee from J. Vully, the Usher, I hear that he has to complain of thy being so very long in writing about ten lines in a Copy, and learning a little spelling,

that two and a half hours are often taken up therewith, which am satisfied thou mightest accomplish in one hour, so that thou hast but little time for the Latin, this has made me sorry, because an hour and a half wasted is a loss thou may have great reason to regret, as well as such a habit continued in of idling thy time must prove of bad consequence and deprive of the satisfaction of reflecting that thou hast spent thy time to the best of thy Capacity, which is both thy duty and interest.

"Thy Usher therefore with me concludes that the writing and spelling shall be the last, that the prime of the morning may be applied to Latin and French, and I do desire thee to be in earnest whilst in the School to apply with industry, that so by overcoming the difficulties thou may begin to taste the sweets of Learning. The Usher desiring to borrow for thy perusal L'Henriade occasions me with sorrow to acquaint thee, that the cousin J. R. Stevens (whose Book it is) by giving way to a slothful disposition in a morning, not accommodating himself to our meals, and indeed by wasting time, has rendered himself so uncomfortable in my family, that I did not chuse to keep him any longer; and he now lodges in an obscure Chandler's Shop, but desire thou wilt keep this information a secret, as we hope he may mend.

"O my Son, there is nothing like doing the best thou can to please those who have the care of thy instruction and thy good at heart, so hoping I shall hear no more complaints of thee, I remain with love, joined by thy Mother and Sister,

"Thy truly affectionate Father,

"JOHN LISTER.

"P.S.—I think I have been half an hour writing this though often interrupted and hope a word to the wise will be sufficient.

"We intended to have sent thee a plumb cake, had we heard a better account but shall now leave it till another time."*

On leaving school, John Jackson Lister was apprenticed to his father's business (of wine-merchant) and therefore had to travel about the country a good deal, and on one of his journeys he visited Ackworth School, near Pontefract, and there fell in love with one of the teachers, named Isabella Harris. This school was one of those maintained by the Quakers, and Isabella was held in high esteem by children, parents and teachers. Her family were natives of Cumberland and apparently not famous, though upright and conscientious.

Seven years after their marriage, the Listers bought an old Queen Anne house at Upton in Essex, and here their second son, Joseph, afterwards Lord Lister, was born and brought up in the Quaker atmosphere, which was very strong in those days (the first half of the nineteenth century)—a very different thing to what it has now become. Friends refused to take oaths or subscribe to the thirty-nine Articles and were therefore excluded from the old Universities, and from Army, Navy and Church, and to some extent from the other professions. Most were therefore in business and, as they lived very simply, often became wealthy. They abjured frivolities such as theatres, dancing, hunting, music, and therefore had all the more time

* "Lord Lister," by Godlee.

for education, and the standard of culture amongst them was uncommonly high. It followed from their way of life that they were somewhat cut off from social intercourse with the world, and this separation was intensified by the fact that they were not expected to marry outside the Society. Hence many Quaker families were related by marriage. Also, their special dress marked them off from the world. It was conspicuous because old-fashioned and extremely quiet in colour. Lastly, the Quaker speech was distinctive. They called it the "plain language" and used no prefixes or suffixes in addressing others, except the word "Friend." "Thee" and "thou" were substituted for "you."

This does not mean that Lister had a miserable childhood; on the contrary, the family life was very happy and healthy, and the children rode, skated, played cricket, took long country walks, and went in largely for "Natural History"—the study of fossils, plants, birds, etc. All through, however, as Sir R. Godlee says, "there was never any question that life was a gift to be employed for the honour of God and the benefit of one's neighbour."

Lister's father was a good instance of the high level of literary and scientific knowledge and achievement reached by some of the Quaker business-men of that period. He left school at fourteen, but found time to study mathematics and optics to such purpose that in 1832 he was made a Fellow of the Royal Society. Further, he knew Latin, French, and German, and was a good artist, both in landscape and portraits. Clearly, contact with such a man was likely to influence his children strongly, and Lord Lister owed much to his father.

Joseph Lister was sent to two private schools and did well. A feature of the second school was the writing of essays, and some of these, written at about the age of fifteen or sixteen, are on topics such as "The Human Structure—Osteology," and "The Similarity of Structure between a Monkey and a Man," and are illustrated with beautiful drawings, showing that he was already interested in anatomy, and at home he used to dissect fish and small animals and mount their skeletons. Thus it can hardly have been a surprise to the family that from his boyhood he wanted to be a surgeon, and, though his father was rather against the idea at first, he gave way when he saw that the boy was serious in his wish, and sent him, at seventeen, to University College, London.

Here Lister spent three years in getting the B.A. degree. His father considered this "humanistic" or literary education a necessity for a medical career, and Lister himself always recommended young men to take an Arts degree if they could afford the time and money before taking up medicine.

In 1848 he began medical work, *i.e.*, very soon after the discovery of *anæsthetics* (ether and chloroform) and when surgery was very rough and ready compared with what it is to-day. The sequel of an operation was also a very different matter to what it is to-day. It seemed to be simply a matter of chance whether patients died or recovered. Their progress was constantly stopped or retarded by inflammation, suppuration, gangrene, and erysipelas. Hence only *absolutely* necessary operations were done, for the risks were so enormous.

In 1852 Lister got his M.B. degree and a Fellowship of the Royal College of Surgeons, and in 1853 he went to Edinburgh to see the work of a famous

surgeon called Syme. He intended staying a month, but actually remained for seven years, so great was his admiration of what he saw at the hospital, for Edinburgh, which has for many years been famous for its medical school, was at that time ahead of London in many ways. Syme made him a house-surgeon at the hospital, and Lister married his daughter, Agnes Syme, and therefore severed his official connection with the Quakers and joined the Episcopalian Church. In 1855 he began an important investigation on *Inflammation*, and it should be remembered here that, like Pasteur, he was fortunate in his wife. Mrs. Lister sometimes wrote for her husband from dictation for seven or eight hours a day and "was most helpful in suggestions as to words and arrangement of sentences."

In 1860 he was appointed Professor of Surgery at Glasgow, where for five years he was engrossed in the more or less routine work of surgery, though he kept up his study of inflammation; but in 1865 came his *greatest discovery*. As we have said, operations in those days were comparatively rare because the simplest was likely to be fatal, owing to blood-poisoning. This was far commoner in hospitals than in private houses, and sometimes whole wards in a hospital had to be closed, and the pulling-down of the whole building was often advocated, so soaked with infection did they seem. Now Lister was most careful to ventilate his wards and to keep them clean, and yet his patients, too, often died from the so-called "hospital diseases," viz., erysipelas, gangrene, blood-poisoning, and lock-jaw. Nowadays these diseases are very rare; then they were so common as to be a perfect nightmare, because though microbes were known, it was *not* known that they caused disease, and this

fact explains why doctors were so helpless in face of these "hospital diseases." The only fact they knew about them was that they were increased by dirt and overcrowding of patients, and it was therefore assumed that foul air caused them.

Further, *surgical cleanliness* as understood to-day was then unknown. One or two jugs and basins and a few towels were all the cleansing apparatus used, and no disinfectants except a little potassium permanganate (Condy's fluid) was ever used. There was no sterilising of instruments, sponges, dressings, etc., and the surgeons wore their oldest clothes, and both they and the nurses went from cases of "hospital disease" to healthy patients with entire promiscuousness, and even backwards and forwards between the dissecting-room and the wards.

The result was that a mortality of 24%–26% of cases of major amputations of limbs was considered very satisfactory in London. In Edinburgh the death-rate after such operations was 43%; in Glasgow, 39%: in Paris, 60%; in Zurich, 46%; in Vienna, 43%. In the Army, the death-rate sometimes reached 75% to 90%, and nobody knew the reason why. Lister, writing of the Glasgow hospital, says: "My patients suffered from the evils alluded to in a way that was sickening and often heartrending," and his mind was full of the desire to get at and remedy the cause of this state of things. He tried every preventive he could think of—more air-space, antiseptic cleansing of wounds, medicine—and all to no purpose. All ended in disappointment and failure.

Then, in 1865, his attention was drawn to Pasteur's work on fermentation and putrefaction, and he saw at once that this might solve his problem on wound-infection. Pasteur had proved that

putrefaction and fermentation were due to the growth of microscopic plants in the decomposing material, and that these "germs" were carried in the air, and that air could be freed from them by filtering, heating or treatment with chemicals, and Lister saw that probably wound-poisoning was due to germs from the air getting into the wound, and that, if so, the thing to do was to so purify the air, the dressing, and everything which came in contact with the wound that no germs got into it. This was the foundation principle of his system of *Antiseptic Surgery.*

He at once began to look about him for a suitable chemical antiseptic, and, having heard that *Carbolic Acid* had been used as a disinfectant for sewage, he tried swabbing wounds with it. This was found to irritate the wound, because strong carbolic acid attacks the body-tissues as well as germs; hence Lister tried a solution of the acid in oil and mixed with carbonate of lime till it was like putty. This, applied to wounds, gave good results, and Lister published his discoveries in the *Lancet,* in 1867, and also read a paper at the Dublin meeting of the British Medical Association, in which he describes the revolution caused in the Glasgow Infirmary thus:—"Since the antiseptic treatment has been brought into full operation, and wounds and abscesses no longer poison the atmosphere with putrid exhalations, my wards, though in other respects under precisely the same circumstances as before, have completely changed their character; so that during the last nine months not a single instance of pyæmia, hospital gangrene, or erysipelas has occurred in them."

The reception given to the new idea by the medical world was, as usual, a mixture of welcome

and disapproval, not unmixed with jealousy. Sir James Simpson, the discoverer of chloroform, was, curiously enough, one of the bitterest opponents of the new system, and his reputation made him a formidable enemy.

Meanwhile, Lister went on elaborating his antiseptic methods, *e.g.*, trying other disinfectants instead of carbolic, methods of making the ligatures with which he tied the ends of blood vessels antiseptic and absorbable, and different forms of dressings. One of his inventions was a carbolic spray, to disinfect the air round a wound. The spray underwent various evolutions; thus it began as a small hand spray, but this, unless he had an assistant, meant that the surgeon had only one hand left free, so then a foot-spray was invented, but it was very hard to work, requiring relays of assistants in a long operation, and soon it was replaced by a "steam-spray," which produced a huge cloud of fine spray, enveloping patient, nurse, surgeon, in fact, the whole room, with a thick fog of carbolic vapour, which was a very inconvenient atmosphere in which to breathe and work. Further, the machine sometimes refused to work, sometimes the vapour was too coarse and wetted the operator and wound, so that the surgeon's fingers were made white and numb, and, though the chloroformed patients could not express an opinion, they must have suffered considerably from the carbolic inhaled. Nevertheless the spray was used all over the world for many years, till in 1880 a German surgeon published a paper protesting against it, and after this many surgeons gave it up, though Lister went on using it till 1887, when he, too, abandoned it because he realised that it was quite ineffective as a killer

of the germs in the air. Also he abandoned the carbolic plaster and substituted gauze soaked with carbolic acid and then dried, and later on replaced it by gauze impregnated with the double cyanide of mercury and zinc, and this is still the dressing used by those who practice "antiseptic" as opposed to the so-called "aseptic" methods. One other antiseptic substitute may be mentioned here because it is so well-known as an ordinary household commodity, viz., Boracic acid; Lister began to use it in 1871. It can be used as a powder, as ointment, or in the fibres of the lint called *boracic lint*, which was first made by Lister.

The antiseptic method was only slowly adopted by other surgeons in England, and the provinces were ahead of London in this matter, especially the North and Midlands, where Lister's own students often got hospital appointments.

The "hospital diseases" on the Continent were at this time even more rampantly destructive than in England, but gradually the antiseptic method was introduced and the results seemed miraculous, e.g., Professor Nussbaum describes the effect of introducing it into Munich in 1875 thus:—"Everything that we had tried against the above-mentioned horrors had proved unsuccessful. The open treatment, the occlusion dressing, the continuous water bath, irrigation with chlorine water or with carbolic acid solution, salicylic acid in powder and in solution, the putting on of Lister's antiseptic materials—carbolic paste, etc.—all, all were unable to combat hospital gangrene and pyæmia. But when, in the course of a single week, with great energy and industry, we applied to all our patients the newest anti-

septic method, now in many respects improved by Lister, and did all the operations according to his directions, we experienced one surprise after another. Everything went well; not a single case of hospital gangrene occurred. Pyæmia and erysipelas were observed a few times at the very beginning, but only, as the result proved, because we did not yet possess the necessary practice in the carrying out of Lister's directions."*

Curiously, France was long in adopting Lister's principles, and Italy was also slow in moving, and in America progress was slower still. In 1877, the Surgeon to the New York and Roosevelt Hospitals wrote: "It is only lately that, in America, attention has been given practically to the teachings of Lister in respect to the treatment of wounds."

In 1869 Lister had succeeded to Syme's post at Edinburgh, and, speaking of his work there, his house-surgeon said: "In the Hospital wards it was not only the healing art which was taught. They were a school of gentleness and human sympathy, and we can well remember the darkening of his countenance as, with stern severity, he rebuked an unthinking student for lifting a broken leg somewhat roughly." In 1877 he was offered and accepted a Professorship of Surgery at King's College Hospital, London. He accepted this largely because he felt that London was still largely unconverted to his antiseptic methods, and he intensely desired that conversion. His work was not exactly easy to begin with, for King's College was a small institution, and Lister in coming to London exchanged crowded classes

* "Lord Lister," by Godlee, p. 339.

of enthusiastic students in Edinburgh for small numbers of comparatively apathetic learners, many patients for few, and hearty co-operation from the nursing staff for chilly lack of sympathy and subservience to red-tape. Gradually, however, the success of his operations, together with his courtesy and humility, broke down prejudice and opposition, and by 1890 the medical world of London was on his side.

Aseptic v. Antiseptic Surgery.—To-day, antiseptic surgery is often spoken of as out-of-date, as having been superseded by the aseptic method. The fact is that the differences between antiseptic and aseptic surgery have been much exaggerated. The truer view is to look on the latter as a development of the former. The essence of the *Antiseptic* method was the destruction of germs by chemical disinfectants either before they reached a wound or so soon after that they had had very little time in which to multiply. There was a difficulty here which Lister had recognised, viz., that the body tissues could, if healthy, do a good deal by themselves to kill germs (phagocytosis) and that strong disinfectant tended to weaken the tissue and decrease the power of its white corpuscles to kill germs. Hence, as time went on, Lister recommended weaker solutions of carbolic, but one school of surgeons held that it was better to use *no* chemicals on a wound, but to rely simply on very thorough scrubbing and washing of the parts, and, by taking very great care over details, excellent results were got by the new method. Really, this is only a modification of the antiseptic method—a modification in which chemical disinfectants play a less important part and heat a greater part—but both have the same end in view

viz., the exclusion of germs from wounds, and *this was the root idea of Lister's work.* The aseptic method, because it involves absolute sterility of every person, place, and thing employed in connection with the operation, entails much more care and trouble than the antiseptic method, and involves far more possibilities of things going wrong, if a nurse, for instance, be careless in the slightest detail, such as covering a vessel of boiled water with an *un*sterilised towel—and some surgeons consider that the results of aseptic surgery are not so uniformly or completely successful as were those of Lister and his immediate followers.

In 1883 Lister was made a baronet, in recognition of his services to humanity.

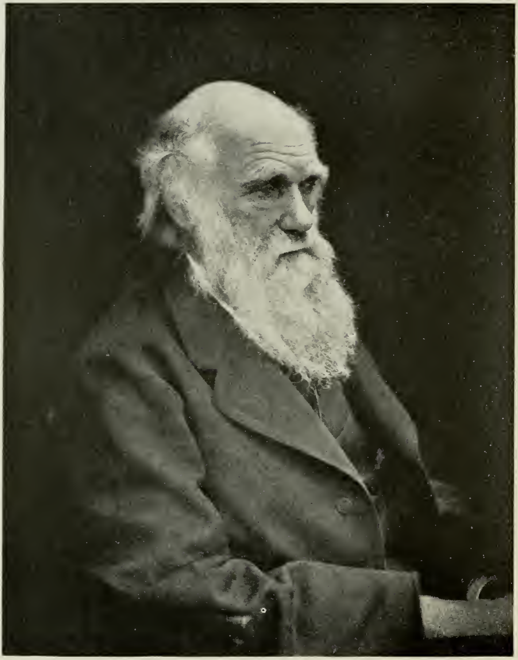
In 1889 a meeting was held in London, in the Mansion House, to discuss the provision in England for the treatment of hydrophobia. Institutes for this treatment existed in most European countries, thanks to Pasteur's work, but, as usual, we were behind the times. However, we were better off than Continental countries in that we were an island, and therefore it was easier to stamp out hydrophobia by strict muzzling and quarantine regulations than it was abroad. It was resolved to raise a fund for a donation to the Pasteur Institute in Paris and to pay the expenses of sending thither hydrophobia patients. The consequence was that £2,000 was sent to the Pasteur Institute. Also the Government was asked to bring in a Bill for the muzzling of all dogs in the British Isles and a quarantine of all imported dogs.

The Committee then suggested that it would be a good thing for England to have an Institute like those already established abroad for investi-

gations of germ-diseases. Here, however, the anti-vivisectionists stepped in and did all they could to stop the Institute being started, on the score that experiments on animals would be made in it. However, in 1891 the *British Institute of Preventive Medicine* was incorporated, with Lister as the first chairman, and began work in 1893, in Great Russell Street. This was the year in which the treatment of diphtheria by antitoxin was begun, and the Institute took a large part in it, for it secured a farm at Sudbury, where the antitoxin was made. In 1897 a new building for the Institute was erected in Chelsea Gardens, and, this being the centenary of Jenner's discovery of vaccination, a National Memorial was proposed, and Lister suggested that it would be a good thing to raise money for research along Jenner's lines, to endow the Institute with this money, and to change its name to the *Jenner Institute.* This was accordingly done, but it caused trouble with a private firm which called itself the "Jenner Institute for Calf Lymph," and so in 1903 the name was again changed to that of the "Lister Institute of Preventive Medicine," and Lister subsequently became President. The present buildings in Chelsea Gardens contain laboratories for the study of bacteriology, etc., and numerous researches are carried on. Also the staff analyse milk for the London County Council and examine blood, sputa, etc., from patients suffering from diphtheria, typhoid, tuberculosis, etc. These examinations are done on behalf of both private doctors and public health authorities. Lately a good deal of work on *food* (e.g., on Vitamines) has been done, and much on *disease-carriers,* viz., people who harbour

disease-germs without being ill—and so are often the cause of epidemics. The Institute now has a farm at Elstree, where sera and vaccines are made for all sorts of diseases.

This brings us to the closing years of Lister's life. When he reached the age of sixty he began to take life more easily. In 1893 Lady Lister died, and this altered the whole course of his life. They had no children and she had been his daily companion for thirty-seven years, entering into his work, looking after his health, and sharing both his anxieties and his triumphs, and with her death he lost heart for fresh work and for social life. Scientific honours were now heaped on him, and in 1897 he was raised to the peerage ; but he made only two important speeches in the House, one on the question of Venereal Disease and one on the Vaccination Bill. In 1898 he received the freedom of Edinburgh. Gradually, however, he retired more and more into private life, and in 1903 he had a serious illness from which he never really recovered, though he lived eight years longer, dying in 1912, at the age of 85. He was buried in the same grave as his wife, at West Hampstead Cemetery, and a Memorial Service was held in Westminster Abbey, where, in the North transept, may be seen the marble medallion of his head.



CHARLES DARWIN

1809-1882

CHARLES DARWIN

1809–1882

CHARLES DARWIN was the son of Dr. Robert Darwin, of Shrewsbury, and was born there in 1809. Dr. Darwin was the son of Erasmus Darwin (1731–1802), also a doctor, and in addition a poet and naturalist—whose observations led him to the theory that plants and animals had, in the course of ages, become changed, and his explanation was that the needs of the living thing stimulate its exertions and these exertions result in improvements which are inherited by the offspring, and increased by their similar exertions; *i.e.*, Charles Darwin's grandfather was a convinced Evolutionist, though his *explanation* of evolution is not that given by his grandson, nor that believed to-day.

Charles Darwin's mother was Susannah, daughter of Josiah Wedgwood, the maker of the well-known Wedgwood china. Thus Darwin came, on both sides, of very capable stock and was hereditarily well-endowed mentally. The father, Robert Darwin, was hardly famous, but was remarkable for keen observation and insight into character, and Charles Darwin always showed very strong affection and respect for him, frequently speaking of him and of his wisdom. Dr. Darwin had six children:—four girls and two boys, of whom Charles was the younger son, the elder, Erasmus, dying at twenty-seven. The mother died when Charles was eight years old and so did not consciously influence the son as much as did the father.

Charles was sent to school in Shrewsbury at eight years old, and he says that at that age his taste for collecting and Natural History was well developed, *e.g.*, he tried to find out the names of plants and collected all sorts of things, such as shells, minerals, coins, seals, eggs, etc. He says of himself that he was humane as a boy, thanks to his sister's teaching, but doubts if humanity is a natural or innate quality ; *e.g.*, he never took more than one egg from a nest, and only collected insects *found dead*. He had a passionate love of dogs, and dogs returned the compliment in the curious way in which animals seem to respond instinctively to affection. He also loved long solitary walks. He thought school life was of very little use in developing his mind, because nothing but classics and a little ancient history and geography were taught—but he worked conscientiously, though he got no pleasure from his work. He was considered a very ordinary boy at school, rather below than above the average. However, some things which he was taught out of school he revelled in, *e.g.*, Euclid, and the poetry of Shakespeare, Thomson, Byron, and Scott, and he says how he regrets that later in life he lost the capacity to enjoy poetry. And from the time when, as a boy of thirteen, he went on a riding tour on the borders of Wales, he enjoyed lovely scenery—and this love remained with him longer than any other capacity for enjoying art. He continued his collecting of Natural History specimens out of school and was roused to an interest in birds by reading Gilbert White's "Natural History of Selborne." He and his brother made a chemical laboratory in the tool-house, and, this getting known at school, he got the nick-name of "Gas" and was publicly rebuked by the head master, Dr. Butler, for wasting time.

At sixteen he left school and went to Edinburgh University for two years, to study medicine, but says that the discovery that his father would probably leave him enough to live on checked any strenuous effort to learn. He found the lectures intolerably dull, but says that in any case reading is far preferable to lectures. He hated seeing operations; in fact, he saw only the beginning of two, for he rushed out before the end, and what he saw haunted him for years, probably because chloroform was then unknown. However, he made friends at Edinburgh with several other men interested in Natural History, and used to collect marine animals and try to dissect them, though he had only a wretchedly poor microscope. In his second year he attended lectures on geology, which also seem to have been very dull and made him decide to give this science a wide berth. This, considering his future interest in Geology and friendship with famous geologists, like Sir Charles Lyell, is rather interesting.

After two years in Edinburgh Dr. Darwin saw that his son was not likely to do any good at doctoring and therefore proposed that he should be a clergyman, and Charles was sent to Cambridge for three years (1828–31) which he says was as great a waste of time, as far as any college-work went, as were his years at school and in Edinburgh. He tried mathematics, but was floored by the first steps in algebra, and he did practically no classics. However, though he did not take botany as a "subject," he went to Henslow's lectures on it and liked them for their clearness and admirable illustrations, and he used to go on the botanical excursions which Henslow organised, sometimes on foot, or in coaches or barges, and he says that

his friendship with Henslow influenced his whole career more than any other circumstance. Henslow was a man of very varied scientific interests—in botany, zoology, chemistry, and geology—and his method was to make numerous careful observations and *then* draw conclusions from them, *i.e.*, the essentially modern, heuristic method. Darwin describes him as no genius, but possessed of excellent judgment, a well-balanced mind and a very high moral character, and he was deeply religious and orthodox.

Besides Henslow, Darwin made many friends, and from them learned to enjoy pictures and music, though he had no " ear " and could not even hum a tune, so that he says it was a mystery how he got any pleasure from music. He lost the capacity in later years, along with that for enjoying poetry. He says " Up to the age of thirty, or beyond it, poetry of many kinds, such as the works of Milton, Gray, Byron, Wordsworth, Coleridge and Shelley gave me great pleasure, and even as a schoolboy I took intense delight in Shakespeare, especially in the historical plays. I have also said that formerly pictures gave me considerable, and music very great delight. But now for many years I cannot endure to read a line of poetry. I have tried lately to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music. Music generally sets me thinking too energetically on what I have been at work on, instead of giving me pleasure. I retain some taste for fine scenery, but it does not cause me the exquisite delight which it formerly did. On the other hand, novels, which are works of the imagination, though not of a very high order, have been for years a wonderful relief and pleasure

to me, and I often bless all novelists. A surprising number have been read aloud to me, and I like all if moderately good, and if they do not end unhappily—against which a law ought to be passed. A novel, according to my taste, does not come into the first class unless it contains some person whom one can thoroughly love, and if a pretty woman all the better.

"This curious and lamentable loss of the higher æsthetic tastes is all the odder, as books on history, biographies, and travels (independently of any scientific facts which they may contain) and essays on all sorts of subjects interest me as much as ever they did. My mind seems to have become a kind of machine for grinding general laws out of large collections of facts. . . . A man with a mind more highly organised or better constituted than mine would not, I suppose, have thus suffered; and if I had to live my life again, I would have made a rule to read some poetry and listen to some music at least once every week; for perhaps the parts of my brain now atrophied would thus have been kept active through use. The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature." (P. 50, *Life of Charles Darwin*, by F. Darwin.)

The occupation which he really pursued with devotion at Cambridge was the collection of beetles, and also he read certain books, like Humboldt's *Personal Narrative*, which stirred in him a burning zeal to add something, however small, "to the noble structure of Natural Science."

After taking his degree he stayed for two more terms at Cambridge and began the study of geology,

and on returning home he began to examine sections and went to North Wales on a scientific expedition with Professor Sedgwick, the famous geologist. This tour, he says, was of decided use in teaching him how to make out the geology of a country.

On returning from this tour he found a letter from Henslow saying that Captain Fitz-Roy was going on a voyage to survey the South coast of Tierra-del-Fuego and then to visit the South Sea Islands and to return by the Indian Archipelago. The object of the voyage was to combine scientific observations with the survey, and hence a naturalist was wanted, and Henslow had recommended Darwin for the post. The naturalist's duties were to collect, observe and note anything worth while from the point of view of Natural History, and Darwin was anxious to get the post, but his father objected, saying that it would unsettle him and make him unwilling to settle down as a clergyman. However, the Wedgwoods came to the rescue and succeeded in overcoming Dr. Darwin's objections, and the voyage of the *Beagle* was probably the most important event in Darwin's life. He says that to it he owed " the first real training or education " of his mind, and lays special stress on the value of his study of the geology of the places visited for developing not only observation but reasoning power. He took with him on the voyage Lyell's *Principles of Geology*. Now Lyell was a revolutionary in matters geological, for he believed that the present-day form and structure of the earth's crust could be explained as due to the action, through millions of years, of the operations of Nature still in progress on the earth's surface, and that we can discover the earth's history by observation of the changes continually taking place to-day.

All other geologists believed that the form of the earth's crust was due to successive cataclysms, *i.e.*, terrific and overwhelming upheavals and destructions of the crust, such as are unknown in historical times. Compare theories of origin of river-gorges, for example. The old school believed that a river-gorge was caused by the tearing apart of the rocks, between which the river ran, by earthquake shocks—whereas Lyell believed that the gorge was slowly carved out by the vertical erosive action of the river itself. Lyell undoubtedly prepared men's minds for belief in Darwin's views on the origin of species. Darwin himself was very soon convinced by his observations on the geology of St. Jago, an island off the West coast of Africa, that Lyell's views were correct. Thence he proceeded to study the geology of South America. At the same time he made large collections of plants and animals which he sent home to England.

The voyage began on September 17th, 1831, and lasted five years, and throughout it Darwin suffered badly from sea-sickness, and some people thought that this accounted for his ill-health in later years, though he did not believe so himself. In spite of the sea-sickness, however, one of his companions on the voyage says that he was never out of temper, and never said one unkind or hasty word to anyone.

The voyage ended in 1836 and Darwin settled in London, and now began the permanent ill-health, which lasted for the rest of his life and forced him in a few years to leave London and live a very quiet life in the country. He suffered from chronic stomach trouble, and this prevented him from ever working for more than a short time each day —and sometimes he was entirely unable to work. Yet, with indomitable courage, he continued his

careful, patient, exact observations, and the total amount of his life-work is enormous.

Three years after his return he married his cousin, Emma Wedgwood, daughter of Josiah Wedgwood, the uncle to whom he was so devoted, and grand-daughter of the founder of the Etruria Pottery Works, and his first child was born in 1839, the child of whom he wrote to a friend in 1840, "He (the baby) is so charming that I cannot pretend to any modesty. I defy anybody to flatter us on our baby, for I defy anyone to say anything in its praise of which we are not fully conscious. . . . I had not the smallest conception that there was so much in a five-month baby."

After six years in London, the family moved to a little village called *Downe*, in Kent, ten miles from the nearest station, which was Croydon. Here he went on working at a book on the *Geology of the Voyage of the Beagle*, which was published in two volumes in 1842. The first of these, which dealt with *Coral Reefs*, has become a classic, though Darwin's opinion of the way in which coral reefs are formed is not the only one. Much discussion on their origin had taken place, but till Darwin's work appeared no reasonable theory had been put forward.

During the voyage of the *Beagle* Darwin had had excellent chances of studying the various coral-formations of the Pacific, of which there are three main types :—

I. Fringing Reefs.
II. Barrier Reefs.
III. Atolls, or Coral-Islands.

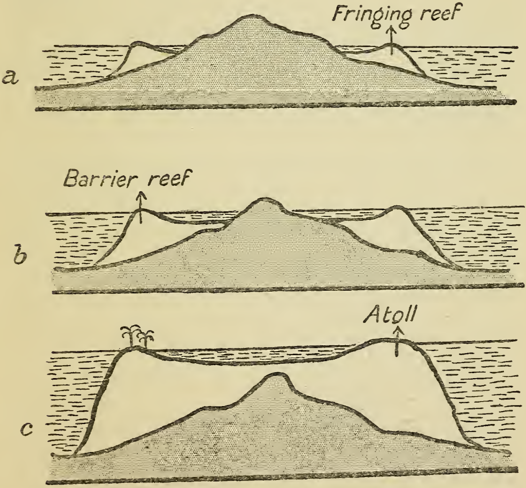
Coral consists of the skeletons of a marine animal and forms reefs often hundreds of miles long, *e.g.*, the Great Barrier Reef that fronts the North East

coast of Australia is 1,250 miles long and from 10 to 90 miles broad. The coral can live only in warm water and at a depth of 100 feet to 120 feet. The surface of the reef is broken up by the waves and becomes covered with a scanty soil on which a scanty vegetation arises.

A *fringing reef* skirts the shore a little distance out to sea, and encloses a shallow lagoon between it and the land.

A *barrier reef* is further out to sea and the lagoon is therefore wider.

An *atoll* is a ring of coral enclosing a circular lagoon.



Diagrams illustrating Darwin's Theory of the formation of Coral reefs (a), (b) and islands (c).

Darwin's theory was that, if the earth's crust is stationary and the sea shallow, the reef grows outwards. If the sea-floor sinks slowly, the corals keep pace with the lowering, raising the reef always to high-water mark. Hence, beginning as a fringing reef with a high seaward edge where the strongest corals live, it becomes a barrier reef, and, as depression continues till the land wholly disappears, we get a coral-ring or atoll.

The rival theory is that of Dr. Murray, the geologist to the famous Challenger Expedition. He pointed out that coral-reefs need not imply subsidence, for the Pacific reefs are usually formed round volcanic islands. He suggested that the wide lagoon inside the barrier reef might be formed by *solution* of the coral by the water charged with carbon dioxide inside, and that atolls might have arisen on land submerged before the corals began to build, such as submarine volcanoes and shoals. The best example of the formation of new land thus is the South part of the peninsula of Florida, where between 12,000 and 15,000 square miles have been reclaimed from the sea in recent geological times. Here, coral reefs *are* first formed on submarine platforms, and these reefs gradually join up. Then the lagoon between them and the land silts up and so disappears, and thus the reef is joined to the mainland.* Probably both Darwin's and Murray's explanations are correct for different cases.

The only other important geological work done by Darwin was embodied in his book on *Earthworms*. This was published in 1881, nearly forty years later, but he had been interested in the work of worms for many years before that date. Thus in 1838 he showed that fragments such as cinders,

* See Lapworth's "Geology," pp. 40-43.

etc., strewed over a meadow, were found after a few years some inches below the turf, and the explanation of his is the central fact in this book. It was suggested by his uncle, Josiah Wedgwood, who propounded the idea that worms, by bringing earth to the surface in castings, undermined objects lying on the surface, and caused them to sink. One reviewer wrote, "In the eyes of most men . . . the earthworm is a mere blind, dumb, senseless and unpleasantly slimy annelid. Mr. Darwin undertakes to rehabilitate his character, and the earthworm steps forth at once as an intelligent and beneficent personage, a worker of vast geological changes, a planer-down of mountain sides . . . a friend of man . . . and an ally of the Society for the preservation of ancient monuments."

In 1846 Darwin turned his attention to his notes on and specimens of animal life, collected during the voyage of the Beagle and ever since his return to England. Whilst in South America he had been much struck by finding great fossil animals with armour like that on the existing armadillos, also by the way in which, as he travelled southwards over the continent, he found that closely allied animals replaced one another, and thirdly, by the character of the animals of the Galapagos archipelago. The Galapagos islands lie in the Pacific, about six hundred miles off the West coast of South America, and Darwin found that each island had its own characteristic population of animals, differing *slightly* from that of any other island, and from that of the continent of South America. He meditated over the explanation of these differences in the species, and came to the conclusion that they all sprang from one ancestral species which had gradually become

modified, i.e., the probability of *Evolution* was borne in on his mind. Here one must remember that Darwin did not originate the idea of Evolution. His own grandfather, Erasmus Darwin, had believed in it, and so had Buffon, Lamarck, Chambers, and many others. The *original* part of Darwin's work was his *explanation* of how Evolution was brought about.

The pre-Darwinian naturalists had believed that variations in plants and animals were caused either directly or indirectly by changes in the environment, e.g., in climate or food-supply. Thus Lamarck argued that changes in the environment produce changes in the habits of animals because they have new wants to satisfy. This means that new bodily structures must be developed, or the old ones must be used in fresh ways, e.g., an animal which has to reach high for its food will develop a long neck through constant stretching, as in the giraffe, and this modification will be handed on to the offspring, so that each generation will have longer necks than the preceding one. Nowadays, this explanation is not accepted because there is no proof that characters acquired in the life-time of the parents are inherited by the children—on the other hand to-day we all accept the *fact* of Evolution, whereas in Darwin's day, in spite of the pioneer's work, the greater part of scientific opinion was against Evolution and in favour of "Special Creation," i.e., the belief that every species had been separately created in its present form and was fixed and unchangeable. There were a few exceptions, notably Sir Charles Lyell, the geologist, and Herbert Spencer, the philosopher, who sided with Darwin.

Darwin now turned his mind to the question

of the cause of the changes and differences noticeable in plants and animals, those differences which often so beautifully fit their owners to live in the particular surroundings and conditions of life in which we find them, and which we call "adaptations to environment." For instance, the leaf of the plant growing under dry conditions tends to be small, thick and fleshy in order to store and prevent loss of water, whilst the submerged leaf of the water-plant is cut up into hair-like segments which refuse to give the current much grip and so save the plant from being uprooted. He came to the conclusion that the raw materials of Evolution were the very small variations and peculiarities which constantly occur amongst members of any family, and which differentiate brother from brother, child from parent, and so on. These he believed were chiefly inborn, though a slight influence might be due to the direct action of the conditions of life, such as food and climate, and a rather stronger influence to habit, use and disuse in strengthening or weakening the various organs of the body. This kind of minute variation is often called a *fluctuation,* to distinguish it from the larger differences which occur at times and are called *mutations,* e.g., the sudden appearance of the copper beech tree in the sixteenth century. Darwin realised that it was very difficult to explain *why* variations appear—and this difficulty is still with us, though partially solved by Mendel—but of the fact of variation there is no doubt. Further, Darwin believed that most variations are passed on to the children by heredity. But still there was no answer to the question as to why some of these variations persisted and increased and became new species and why others disappeared.

Feeling that the best way to solve the problem was to collect all the facts bearing on the variation of plants and animals, both wild and domesticated, Darwin proceeded to do so by every possible method, e.g., by printed enquiries, talks with breeders and gardeners, and wide reading, and soon he saw that *Selection* was the key to the breeding of new species of domestic animals and cultivated plants, i.e., that the farmer or breeder who wants to get a new type of sheep, or cattle, or horse, selects from his flock or herd the animal which is nearest to the desired type, and breeds from this, and continues sometimes through many generations to select for breeding purposes only those animals which show an increase of the desired characters. For some time, however, Darwin could not see how selection could be applied to wild plants and animals. Then, in 1838, he read a book by Malthus on "Population" which pointed out that the size of a population was limited by the available means of support, *e.g.*, food-supply, and by other "preventive checks," especially in savage races; in other words that there was a *struggle for existence* amongst human beings. At once Darwin saw that this applied to *all* living things, and it struck him that, under such a struggle, favourable variations would tend to be preserved and unfavourable ones to be destroyed, and, since the parents hand on their variations to their children, the result will be that in the course of time we get *new species*. His theory of the Origin of Species may be summed up in his own words:—"As many more individuals of each species are born than can possibly survive, and as, consequently, there is frequently recurring a struggle for existence, it follows that any being,

if it vary, however slightly, in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be naturally selected. From the strong principle of inheritance any selected variety will tend to propagate its new and modified form."

Under the term, "struggle for existence," Darwin included such things as the fight for food, air and light which goes on amongst seedlings growing crowded together, the fight between animals and their natural enemies, *e.g.*, rabbit v. weasel, the fight with disease germs which most living things have to endure, and so on.

As we said just now, the originality of Darwin's work lay in this idea of *Natural Selection* or *Survival of the Fittest*, as the sieve acting on variations to preserve some and destroy others.

At this point Darwin showed his characteristic conscientiousness, for he decided not to write anything about his new theory till he had collected more facts in support of it. In 1856 Lyell advised him to write out his views, and he began to do so, but two years later, in 1858, he was greatly taken aback at receiving a letter from Mr. Alfred Russell Wallace, who was then in the Malay Archipelago, enclosing an essay "*On the Tendency of Varieties to depart indefinitely from the Original Type*," and this essay contained exactly the same theory as his own. In the covering letter Wallace asked him, if he approved of it, to forward the essay to Lyell to read. This Darwin did—realising that he had been forestalled as a result of his long delay in publishing his work, and he was now torn by doubts as to what he could honourably do in the matter of publishing his own work. Finally, a joint paper

by Darwin and Wallace was read to the Linnæan Society on July 1st, 1858. The interest roused was intense, but there was no discussion at the meeting because, as one member said, "the subject was too novel and too ominous for the old school to enter the lists before armouring. After the meeting it was talked over with bated breath." Darwin wrote in his autobiography: "Our joint productions excited very little attention, and the only published notice of them which I can remember was by Professor Houghton of Dublin, whose verdict was that all that was new in them was false, and what was true was old. This shows how necessary it is that any new view should be explained at considerable length in order to arouse public attention."

Wallace throughout acted with admirable generosity, being most anxious to keep his own work in the background so that Darwin should have all the credit. Subsequently, he published a fascinating book on his own work in the tropics and called it *Darwinism*.

In 1859, true to his opinion that a new view should be explained at length, Darwin published the best known of all his books, *The Origin of Species*, which from the first sold enormously, has been translated into almost every European language, and roused storms of opposition, ridicule and misrepresentation, both from the scientific and the religious worlds. This was because it forced people to give up their old belief that the different species of plants and animals had all been separately created, and this was supposed to contradict the account of Creation given in the book of Genesis. Now that careful study of the Bible has shown that the beautiful creation story is an allegory full of

spiritual truth, but not a literal scientific statement, we no longer feel any opposition between Evolution and Religion, and find it hard to understand the bitterness of controversy roused by *The Origin of Species*.

The theory has been modified since Darwin's day; thus we now believe that the raw materials of evolution are not the tiny fluctuations which occur constantly in all living things so much as the larger changes, or mutations, which occur less often, though they are much more frequent than was once supposed. This gets rid of one of the chief difficulties about Darwin's theory, viz.:—That a very small variation is likely to be of so little use that it would not be preserved by Natural Selection.

Another difficulty about the original theory was that variations would be likely to disappear as the result of their owners mating with individuals not having the variation in question—but Mendelism has removed this difficulty by showing that many variations do not blend as the result of marriage but are handed on intact to a certain proportion of the descendants of the marriage.

Darwin's later books include the *Fertilisation of Orchids* (1862), in which he shows how perfect are the arrangements for ensuring cross-pollination in orchids, and attributes this to Natural Selection. *Climbing Plants* (1875). *Variation of Animals and Plants under Domestication* (1868), in which he gives the theory of heredity which he calls Pangenesis. The essence of this theory is that the reproductive cells of any living thing contain "gemmules," or particles, from every cell of the body, and that these gemmules give rise, when they germinate, to cells like those from which they were

derived, and so the characters of one generation are transmitted to the next. This idea had no direct evidence to support it and was difficult to accept because the gemmules, if they are all to be packed into a germ-cell, would have to be almost inconceivably small. Hence it never gained wide support, but it was important because it stimulated other workers to attack the problem of heredity.

The best-known of the later theories of heredity is Weissmann's theory of the *continuity of germ-plasm*, which means that "the germ-cell of one generation gives rise not only to the body of the next, but also directly to its germ-cells, so that the body does not produce germ-cells, but only contains them."* Hence, no change which does not affect the germ-cells can be inherited, and it follows that changes produced in the individual by the action of the environment or by use or disuse of organs will not be inherited as such, *i.e.*, "acquired characters" are not inherited. Here, however, a word of warning is useful; it is quite likely that environment *can* affect the germ-cells, though *how* they will be affected is not known. For instance, lack of food or the presence of large amounts of alcohol in the mother's blood may influence her germ-cells—but it is a proved fact that very many changes produced in the parent by environment are without any influence on the germ-cells. This modern theory of heredity obviously has social implications of considerable importance, *e.g.*, for the reformer who hopes to regenerate Society simply by improving man's environment. Environment, though always important, is only one of the two factors shaping the individual; and it is the lesser of the two when it comes to the shaping of the children

* "Heredity," by Doncaster, p. 119.

of that individual. For the race, Nature is always more important than Nurture.

Let us now return to Darwin's work. In 1871 he published the *Descent of Man*, expressing his belief that man was no exception to the general law that species were alterable, *i.e.*, that he was descended from an animal ancestor which also gave rise to the anthropoid apes (*i.e.*, the higher monkeys, like the chimpanzee and the gibbon). This book roused no opposition, which shows how much public opinion had been influenced by the *Origin of Species* in the twelve years since its publication.

In 1878 there appeared *Insectivorous Plants*, and in 1881 *The Effects of Cross and Self Fertilisation*, which described the wonderful arrangements for carrying pollen from one plant to another and the comparative weakness of seeds formed by self-fertilisation.

In 1880 Darwin and his son, Francis, published the *Power of Movement in Plants*, which was a development of the ideas put forward in his earlier book, *Climbing Plants*.

I shall end this outline of Darwin's life and work with some extracts from his autobiography which shed much illumination on his mind and character.

"On the whole I do not doubt that my works have been over and over again greatly over-praised. . . . Whenever I have found out that I have blundered, or that my work has been imperfect, and when I have been contemptuously criticised, and even when I have been over-praised, so that I have felt mortified, it has been my greatest comfort to say hundreds of times to myself that 'I have worked as hard and as well as I could, and no man can do more than this.'"

After giving a list of his books he says, " I have as much difficulty as ever in expressing myself clearly and concisely; and this difficulty has caused me a very great loss of time; but it has had the compensating advantage of forcing me to think long and intently about every sentence, and thus I have been led to see errors in reasoning in my own observations or those of others. There seems to be a sort of fatality in my mind leading me to put at first my statement or proposition in a wrong or awkward form." Surely an encouraging admission to those who are not gifted with natural clarity of style—and a crushing reply to those who argue that style in science can be ignored. That need of clearness and honesty of speech is felt by all true scientists and is one of the moral assets of a scientific training.

Speaking of his own mental equipment, Darwin says, " I have no great quickness of apprehension or wit which is so remarkable in some clever men, for instance, Huxley. I am therefore a poor critic —a paper or book, when once read, generally excites my admiration, and it is only after considerable reflection that I perceive a weak point. My power to follow a long and purely abstract train of thought is very limited, and therefore I could never have succeeded with metaphysics or mathematics. My memory is extensive, yet hazy— it suffices to make me cautious . . . and after a time I can generally recollect where to search for my authority.

" Some of my critics have said ' Oh ! he is a good observer, but he has no power of reasoning ! ' I do not think that this can be true, for the *Origin of Species* is one long argument from the beginning to the end, and it has convinced not a few able men.

No one could have written it without having some power of reasoning. . . .

"Therefore, my success as a man of Science, whatever this may have amounted to, has been determined, as far as I can judge, by complex and diversified mental qualities and conditions. Of these, the most important have been—the love of Science—unbounded patience in long reflecting over any subject—industry in observing and collecting facts—and a fair share of invention as well as of common sense. With such moderate abilities as I possess, it is truly surprising that I should have influenced to a considerable extent the belief of scientific men on some important points."

When one reflects that Darwin created a new epoch in Biology, and that all modern Science-of-life practically dates from the publication of the *Origin of Species*, these quotations make very vivid the humility and honesty which characterised him.

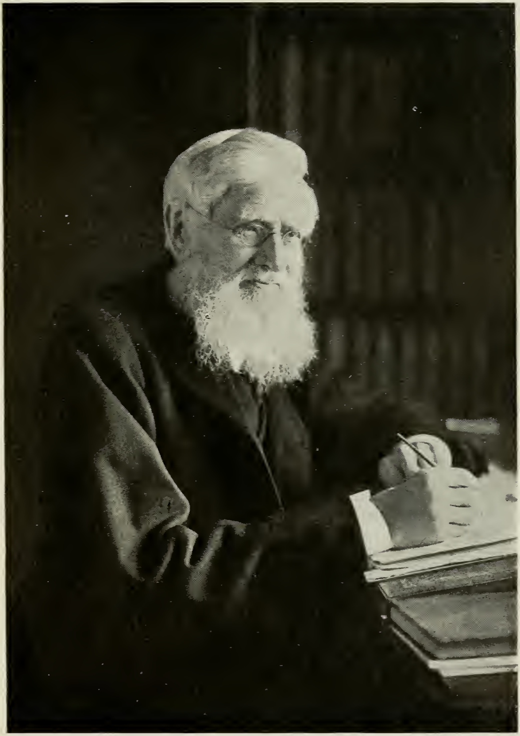
He died in 1882, at the age of seventy-three, and his body is buried in Westminster Abbey, in the North aisle of the nave.

ALFRED RUSSEL WALLACE

1823–1913

WALLACE will always hold a unique place amongst scientists for two outstanding reasons: he evolved, independently of but at the same time as Darwin, the *Theory of Natural Selection* to explain how new species of plants and animals come into being—and this was a scientific achievement of the first rank—and then, with a generosity and absence of egotism even rarer than his intellectual gifts, he not only agreed to a joint publication of their results (his own paper was sent to England for publication before Darwin was ready with the *Origin of Species*), but calmly saw the lion's share of credit given to Darwin and remained a friend and admirer instead of a rival. It is this double claim on our admiration which makes him worthy, above most men, of our remembrance, and a source of inspiration when we are ourselves in danger of falling victims to the smallnesses which do so easily beset us. So let us try to get a picture of the man and his work into the gallery of our minds.

Wallace was born in 1823, fourteen years after Darwin. His father was a lawyer, but the family history does not show the intellectual distinction which is obvious in that of Darwin. It is said that, rather, the family lacked natural energy and that probably it was only the grip of a great interest in



ALFRED RUSSEL WALLACE
1823-1913

life which enabled Wallace to pour into his work the physical and mental force which it needed. If so, it is a striking testimonial to the value to the world of enthusiasms, definite aim in life, keenness, interest—whichever term you prefer. The family lived at Usk in Monmouthshire till Wallace was six years old and then moved to Hertford, where he was sent to the Grammar School. Those were the days of "hardness" in education—at least physically—for school began at 7 a.m. and artificial light was obtained by each boy bringing his own candle. Like Darwin, Wallace did not love the school-work and thought it of very little value, especially geography, which was taught in the bad old way This is a damaging criticism of that way, when we remember his contributions to our knowledge of geography and geology, and realise his capacity for interest in these subjects, if only they had been reasonably well taught.

Out of school the boy read enormously, and this was easy because his father was the town-librarian. His second hobby was carpentry and the making of various mechanical models, a taste which was of great practical value as a preparation for his future life in the wilds.

Wallace was one of a family of nine, always rather poor, and during the last part of his school-days he had to take the position of pupil-teacher in order to reduce his fees, and he left school at fourteen and at once had to think about earning a living. We cannot therefore put down his scientific work to the credit of any special educational or hereditary advantages. In these matters Wallace was distinctly worse equipped than was Darwin. After leaving school he paid a short visit to an elder brother in London, where he came into

touch with Robert Owen, the famous socialist, and probably this planted the seeds of his own extremely radical and socialistic views. Then he joined another brother in Bedfordshire and began land-surveying. This work improved his health, which was never very good, and was a useful training in observation. Further, Wallace here developed a new interest in Nature ; he made a sun-dial and telescope and thus began a life-long interest in astronomy ; he went for long solitary rambles on which he collected plants, and soon he began a dried collection. He tells of the thrill of joy which the discovery of a new plant gave him, and it was now, too, that he first became interested in Orchids, through reading of them in gardening papers and catalogues. He speaks of their " weird and mysterious charm " which helped to create a longing in his mind to visit the tropics.

In 1844 there was a sudden slump in land-surveying and Wallace therefore had to give it up and turn to teaching as a means of livelihood, and it was during this stage of his career that he became interested in mesmerism and so took the first step towards his later conversion to spiritualism. It was now, too, that he met Mr. W. H. Bates, an enthusiast in the study of insects. This friendship led to a plan for a joint expedition to the Amazon in order to collect speciments of plants and animals and also facts which might help to solve the problem of the *Origin of Species*. Expenses were to be met by the sale of the specimens collected and sent home.

The two friends set out in 1848 from Liverpool and after a month's voyage reached Para, a town at the mouth of the Amazon. Here they spent some time in exploring the islands at the mouth of the river and then proceeded to longer journeys,

spending altogether four years in strenuous collecting and observation. Wallace returned to England in 1852. On the voyage back the ship took fire and he had to spend ten days in an open boat, besides losing all the specimens he was bringing home.

On reaching London he settled down to arranging the specimens which he had sent home before his own return and to writing an account of his four years abroad. This was published in 1853 under the title, *Travels on the Amazon.* In it he describes his disappointment at his first view of the tropics, but points out that one needs time and use of eyes and brain before one can really grasp the interest of a new country, and directly he got out into the forests round the town he found himself fascinated by new plants and especially butterflies, and in two months' time we find him packing the first collection of insects to be sent home to England.

Next, he went on a canoe-voyage up the Trocantius, a tributary of the Amazon, and visited the island of Mexiana, famous for its birds, of which he got seventy specimens in ten days. But Wallace's interests always included humanity, and he comments on the negro and Indian inhabitants and their characteristics and customs, as well as describing the plants, birds, insects and scenery of the Amazon. For instance, he notes that the slaves were often as happy as children and better off than many a free man, but comes to the conclusion that this does not justify slavery, and that it is never right to keep grown men in a state of unthinking childhood, because it is only responsibility and self-dependence that call out the highest powers and energies. Man needs " the struggle for existence " if he is to develop to his best.

Now came longer voyages up the Amazon itself and the collecting of more specimens, the party being kept in excellent health in spite of the intense heat, and this fortunate state of things Wallace puts down to the credit of constant exercise, good food, and pure air. Next, he planned to go up the Rio Negro, a tributary of the Amazon, and after various delays owing to leaky canoes, the difficulty of getting Indian crews, etc., he reached its mouth on the last day of 1849. Here he stopped till August, in the town of Barra, and then set out with a Portuguese trader to go up the Rio Negro, a comparatively unknown region, taking in the canoe loads of the articles popular amongst the half-civilised or savage inhabitants of the country. On the voyage he continued his observations of men and things, noting for instance the fine type of half-breed produced by the mixture of Indian and Saxon blood, and collecting, drawing, and describing one hundred and sixty species of fish. He saw many others and concluded that the Rio Negro probably contains five or six hundred, whilst every other tributary of the Amazon has its own special species.

Wallace's next voyage was up the Uaupés, into still less known regions, which gave him the chance of seeing the Indians in a more primitive and less civilised state than any he had yet encountered, and of collecting live plants and animals as well as dead specimens. He endured discomforts and illness from dysentery and fever with the heroic patience and self-reliance which is demanded in a white man isolated amongst natives ignorant of all rational care of the sick, but he wisely resolved never again to travel in such wilds without one civilised companion. To illness were added hurri-

canes, cataracts, mosquitoes, and all the practical difficulties involved by food, labour and transport in a tropical country where there are none of the conveniences to which we are accustomed. The Indian boatmen thought nothing of decamping without notice, so causing endless delays, and Wallace gives an amusing account of his difficulties in looking after his menagerie of live parrots, monkeys, etc. He was tremendously impressed with the agricultural possibilities ot the country and with their neglect at that time and says that this neglect was specially extraordinary since the white inhabitants were Portuguese, a nation which a few hundred years ago were leaders in enterprise, discovery and commerce. He concludes that they still have these capacities, but coupled with dislike for agricultural and mechanical work, which has now dragged them down from their once high estate. He notes also that drinking, gambling, and lying are rampant—besides trickery, cheating, and debauchery of every description. Finally, on the 2nd July, 1852, he reached the mouth of the Amazon once more, and on the 12th set out on the homeward voyage to England—that disastrous voyage on which he experienced the horrors of fire at sea. All the animals and specimens collected were lost, though crew and passengers were saved after drifting about for ten days in boats. The book ends with a description of the physical geography, geology, climate, vegetation, zoology, and aborigines of the Amazon valley. He notes that the Indian in the neighbourhood of civilisation tends to degenerate, but says that when one meets him in his truly uncivilised state he is a fine creature both physically and in disposition.

Having finished this first book, Wallace made

plans for another foreign journey, and, after studying the birds and insects at the British Museum, decided that Singapore would be a good place to start from, since the district was both healthy and mostly unexplored, and in 1854 he set out, reached Singapore, and finally decided on Ternate as headquarters. The Malay Archipelago in those days was a dangerous and exciting region for white men, the seas were full of pirates, and on land were tribal feuds, hardships and risks of many kinds—but in the midst of these Wallace spent eight more or less solitary years, gathering during that time an enormous amount of information and specimens. Unfortunately his health was poor throughout the whole time, and this made work infinitely harder—as did his loneliness. He had no escort or government protection and so had to rely on his own wisdom and judgment in dealing with natives, but his joy in and enthusiasm for his work more than counterbalanced the drawbacks, and the results may be read in his books on the *Malay Archipelago, Island Life,* the *Geographical Distribution of Animals,* etc.

Perhaps the most interesting result was his discovery that the islands fall into two groups, Eastern and Western, the former being Australian and the latter Asiatic as regards their animal inhabitants. The narrow belt of water between the two groups is called " Wallace's Line." Borneo and Bali are on the West, Celebes and Lombok on the East of the line.

As in South America, so here his human interests were strong ; he made friends with Rajah Sir James Brooke of Sarawak, whom he greatly admired. He describes the reverence in which Brooke was held by the natives, some of whom think

"he is as old as the mountains," can bring the dead to life, etc. As Wallace remarks, "It is a unique case in the history of the world for a European gentleman to rule over two conflicting races of semi-savages with their own consent, without any means of coercion and depending solely upon them for protection and support, and at the same time to introduce the benefits of civilisation and check all crime and semi-barbarous practices." He calls Brooke "a gentleman and a nobleman in the noblest sense of both words."

Natural Selection.—Now let us try to see how the idea of Natural Selection grew in Wallace's mind. As a young man of twenty-four we find him writing of "my favourite subject—the variations, arrangements, distribution, etc., of species," but not till 1855, *i.e.*, eight years later, do we find any published work on this subject. Then he wrote an article called *The Law which has Regulated the Introduction of Species*, for the *Annals and Magazine of Natural History*, one of the chief English scientific papers. In this he develops the idea of species of living things being related to one another in the same way as are the leaves and twigs and branches of a tree—branches springing from the trunk, twigs from the branches, leaves from the twigs—and originating in succession. He points out that "to discover how the extinct species have from time to time been replaced by new ones down to the very latest Geological period is the most difficult and at the same time the most interesting problem in the natural history of the earth."

As Mr. Marchant says, in this article we can see "a great generalisation struggling to be born"; but the only recognition of it was a letter from Darwin, who says he can see that he and Wallace

"have thought much alike." Wallace was extremely pleased at getting this letter, which was practically the beginning of the correspondence between the two men. However, three years later, the great generalisation was born in what at first sight seems unlikely circumstances, for Wallace was ill with an attack of intermittent fever at Ternate when the solution flashed upon him, *i.e.*, the idea of Natural Selection as an explanation of the way in which new species were preserved; in other words, he realised that animals breed so rapidly that an enormous number must die every year to keep down the number to that actually existing, and that those animals would die which were less fitted for the struggle for food and mates and with enemies, climate, etc., whilst those which were better fitted for this struggle would survive. His experience as a collector had convinced him of the occurrence of a large amount of variation in animals—so here was the raw material for new species, whilst the environment provided the sieve which should filter the fit from the unfit. He says, "The more I thought over it the more I became convinced that I had at length found the long-sought for law of Nature that solved the problem of the Origin of Species. For the next hour I thought over the deficiencies in the theories of Lamarck and of the author of the *Vestiges*, and I saw that my new theory supplemented these views and obviated every important difficulty. I waited anxiously for the termination of my fit so that I might at once make notes for a paper on the subject. The same evening I did this pretty fully, and on the two succeeding evenings wrote it out carefully in order to send it to Darwin by the next post, which would leave in a day or two."

This letter reached Darwin at Downe, on June 18th, 1858, and it must have come as a thunderbolt to him, for it contained precisely his own Theory of Natural Selection, which he had written down in 1842 but not published, having spent the intervening years in collecting proofs and facts bearing on the theory. These are discussed in his book on *The Origin of Species.* Writing to Sir Charles Lyell on the same day, Darwin says, "So my originality is smashed," and adds that he will send Wallace's paper to any journal its writer chooses. He wrote to the famous botanist, Sir Joseph Hooker, saying much the same—but these two friends persuaded him that it would be unjust to himself to abandon all claim to the discovery of the Theory of Natural Selection, and that a joint publication in his and Wallace's names should be made, as a compromise. This plan Wallace promptly agreed to, and the joint paper was read before the Linnæan Society, but, though great interest was aroused, no discussion took place, for "the subject was too novel, too ominous, for the old school to enter the lists before armouring."

Darwin was deeply touched by Wallace's attitude, as shown by a letter in 1859, in which he says, "You cannot tell how much I admire your spirit in the manner in which you have taken all that was done about publishing our papers," and from this time onwards we find the two discoverers corresponding up to the year before Darwin's death, and throughout all that time the attitude of the two men, who might so easily have been rivals, is that of mutual admiration and friendship. This striking appreciation of each other's work was well described on the 50th anniversary of the reading of the original joint paper. The event was cele-

brated in 1908, by the Linnæan Society, at a gathering attended by many distinguished scientists, and Wallace was presented with the first Darwin-Wallace medal. The President, in making the presentation, said "There is nothing in the history of Science more delightful or more noble than the story of the relations between yourself and Mr. Darwin . . . the story of a generous rivalry in which each discoverer strives to exalt the claims of the other. . . . You, on your side, always gave credit to him and under-estimated your own position as the co-discoverer. I need only refer to your calling your great exposition of the joint theory, 'Darwinism,' as the typical example of your generous emphasising of the claims of your illustrious fellow-worker. . . ."

In his reply to this speech, Wallace once more reminded the audience that the *idea* of Natural Selection occurred to Darwin nearly twenty years earlier than it did to himself, and that during the whole of that time Darwin had been laboriously collecting evidence, both by experiments and from books, as shown in his *Origin of Species*. He compared himself to the "young man in a hurry" and Darwin to the painstaking and patient student, and said that he should consider it quite fair if their respective shares in elucidating Nature's method of development were estimated according to the time each had spent on the problem before publishing the results, viz., one week to twenty years.

Sir E. Ray Lankester, speaking at the same meeting, said "Throughout all their arduous work and varied publications upon the great doctrine which they on that day unfolded to humanity . . . the same complete absence of rivalry characterised these high-minded Englishmen, even when in some

outcomes of their doctrine they were not in perfect agreement . . . I think I am able to say that, great as was the interest excited by the new doctrine in the scientific world, and wild and angry as was the opposition to it in some quarters, few, if any, who took part in the scenes attending the birth and earlier reception of Darwin's *Origin of Species* had a prevision of the enormous and all-important influence which that doctrine was destined to exercise upon every line of human thought."

Charles Kingsley, writing to Wallace in 1869, says, "Let me, too, compliment you on the modesty and generosity which you have shown in dedicating your book (*The Malay Archipelago*) to Darwin and speaking of him and his work as you have done. Would that a like unselfish chivalry were more common—I do not say amongst scientific men, for they have it in great abundance, but—in the rest of the community."

As already said, Wallace did not always agree with Darwin, and one of the points on which they differed was the origin of the mental and moral qualities in man. Wallace did not believe that these had evolved from lower animal instincts and characteristics, but that they had had another origin, in the unseen universe of Spirit, and had developed under the guidance of a superior intelligence.

In 1886 he visited America, to give a course of lectures on Evolution, and these he published in book-form on his return in 1889 under the title *Darwinism*. The book is a fascinating one—perhaps the most so of all Wallace's writings, and is well worth reading.

Character and Home Life.—The picture of Wallace in his own home, as given by his children, is singu-

larly attractive. He was very fond of his home and of his garden, very independent in small matters which he could do for himself, a great walker and lover of scenery. In 1876 the family went to live at Dorking for a year or two, then moved to Croydon for four years, then to Godalming in 1881. Here his next-door neighbour wrote of him: "Nothing disturbed his cheerful confidence in the future and nothing made him happier than some plan for reforming the house, the garden, the kitchen-boiler or the universe. And, truth to say, he displayed great ingenuity in all these enterprises of reformation. . . . With the same confidence he made up his mind upon many a disputable subject; but, be it said, never without a laborious examination of the necessary data and the acquisition of much knowledge. . . . His power of handling masses of details and facts, of showing their inner meaning and the principles underlying them, and of making them intelligible was very great. . . . Another very noticeable characteristic of his . . . was his apparently unfailing confidence in the goodness of human nature."*

In addition to the hobby of reformation described above, he loved good novels and poetry and was many-sided in his interests, which included psychical research, spiritualism, phrenology, and social and political reform. In these last matters he was curiously credulous, unscientific, and unpractical, and one regrets that he should have written books on them which cannot be regarded as serious contributions to knowledge.

In disposition he was cheerful, optimistic, remarkably even-tempered and patient with ignorant people, sympathetic, incurably young and

* Marchant's "*A. R. Wallace. Letters and Reminiscences.*"

lacking in conceit in spite of the many honours conferred on him, *e.g.*, Fellowship of the Royal Society and the Order of Merit. His whole mind loathed materialism, and, as Mr. Marchant says, "Profound contemplation of nature and of the mind of man led Wallace to belief in God, to accept the Divine origin of life and consciousness, and to proclaim a hierarchy of spiritual beings presiding over nature and the affairs of nations."

Wallace died in 1913, at the age of 90, in his picturesque home at Broadstone, near Wimborne. It was suggested that he should be buried in Westminster Abbey, beside Darwin ; but his family did not wish this, and his grave lies in Broadstone cemetery. In 1915 a medallion of Wallace was placed in the North aisle of Westminster Abbey, next to that of Darwin.

JOHANN GREGOR MENDEL

1822–1884

WHILST in England Darwin was working out his explanations of how plants and animals handed on their characters to their offspring by "Pangenesis," an Austrian monk named Johann Gregor Mendel was employing his spare time in experiments on plant-breeding, which laid the foundations of our modern theory of heredity.

Mendel was born in 1822, in Austrian Silesia, and was thus thirteen years younger than Darwin. His father was a small peasant proprietor with a special interest in fruit-culture, and he gave his son the best possible education. At the age of twenty-one he was admitted as a monk to the monastery of Brünn, in Bohemia, with a view to his taking part in the educational work of the institution, and in 1851 he was sent to the University of Vienna for two years, to study Mathematics, Physics, and Natural Sciences. Then he returned to Brünn and became a teacher, especially of Physics, in the Realschule. He was a good teacher, as proved by the keenness of his pupils, and he continued in this work till he was elected Abbot in 1868.

It was in the garden of the monastery that he carried out his plant-breeding experiments. Those on peas lasted for eight years, and then, in 1865, he laid the results before the Brünn Society, and

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published them in 1866, but they attracted little attention from the scientific world and were simply over-looked and forgotten for thirty-five years. This neglect was very likely due in part to the fact that the interest and attention of all scientists were, at the time, absorbed in Darwin's work. People have often wondered what effect Mendel's discoveries would have had on Darwin if the latter had ever heard of them. However, in 1900, six years after Mendel's death, three botanists in the course of their researches into heredity and breeding re-discovered his work and grasped its importance. Curiously enough, the discovery was made independently, but at the same time, by de Vries in Holland, Correns in Germany, and Tschermak in Austria—and then at once Mendel leapt into fame.

His experiments consisted chiefly in "crossing" different varieties of peas, *i.e.*, in fertilising the ova of one variety with the pollen from another variety. He then planted the seeds which grew on the cross-fertilised plant and observed how the characters of the parent plants showed (or did not show) in their children-plants, as these developed. The result was that he found that certain characters of the parents remained distinct and showed no tendency to blend in the children, *e.g.*, if a tall variety of pea were crossed with a short variety, the children were either tall or short, but not midway between the parents in height; if a purple-flowered variety were crossed with a white-flowered variety, the children were purple or white but not of intermediate tints; and many other pairs of characters were found to behave in the same way, *i.e.*, as indivisible units, and this statement is known as the law of *Segregation of Characters*. This does not mean that every character of every plant or

animal behaves as a "unit," but where they blend or combine they are probably not really units at all but groups of two or more characters, which we have not yet learned to distinguish ; *e.g.*, colours often seem to blend instead of remaining distinct, because each is due to a *group* of characters—but one can tell what the colour of the children will be from careful study of the parent colours.

A few details of Mendel's experiments will help to explain how he reached his conclusions. He chose the common or garden edible pea as specially suitable, because it is naturally self-fertilising, *i.e.*, the seed is formed as the result of union between the ovum and the pollen-nucleus of the same flowers, instead of by union of ovum and pollen-nucleus of different flowers. Most plants have developed the latter habit of fertilisation, the transference of pollen from the flower where it is formed to that which it fertilises being brought about by insects or wind. Now the Pea, being an exception to the general rule of cross-fertilisation, was a comparatively simple plant on which to perform fertilisation experiments, because the worker would not have to guard against insects or wind cross-fertilising the plant and so upsetting the experiment. Other advantages about the Pea, from Mendel's point of view, were that it is hardy and has a good many varieties showing definite differences, *e.g.*, in height, colour of seeds, smooth or wrinkled seeds, etc. This made it easy to cross varieties of Pea showing sharp contrasts and to watch how the next generation inherited the characteristics of the parents.

E.g. One series of experiments was made by crossing tall and dwarf varieties of pea. The tall variety is about six feet high, whilst the dwarf is

not more than two feet high. Mendel chose a true breeding tall plant with young flowers whose stamens had not yet opened to let out their pollen, and cut off the stamens. Then he scattered pollen from a flower of a short plant on the stigma of the flower from which he had removed the stamens. The seeds which developed were hybrids, *i.e.*, the offspring of different varieties, and when ripe they were sown and in time grew into new Pea plants. Now here we get a very striking fact—this first generation were *all tall* plants, *i.e.*, though one parent had been short, the shortness seemed to disappear entirely in the children, which all took after the tall parent—and so Mendel called tallness a *dominant* and shortness a *recessive* character, because it disappeared in the first generation after the cross. He let the tall hybrids self-fertilise and produce seeds naturally and collected and sowed these seeds, and now again a striking result occurred, for some of the plants which developed in this second generation were short and some were tall, but none were intermediate, *i.e.*, the short plants showed the characteristics of one grandparent, the " recessive " character reappearing after, as we say, skipping a generation. Also, however many seeds were planted, there was always the same proportion of tall and short plants, viz., 3 : 1.

Continuing his experiments, Mendel let the second generation self-fertilise and collected the seed of each plant separately and next year sowed it separately and so got a third generation of plants, and it was this patient, careful dealing with each plant separately that, as Professor Punnett points out, showed Mendel the new truth which made him the founder of the modern science of heredity. He found that the seeds of the short peas all " bred

true," *i.e.*, grew into short plants, whilst one-third of the seeds of the tall peas "bred true," *i.e.*, gave tall plants, and two-thirds gave a mixture of tall and short plants, in proportion 3 : 1. Altogether Mendel tested, in the way that has just been described, seven different pairs of contrasting characters in peas, and in each case found that they were handed on from parent to child in exactly the same way as were tallness and shortness. The whole result can be shown clearly in tabular form, thus :—

Let TT = a tall plant which breeds true, *i.e.*, comes of a stock which always produces talls.

Let tt = a short plant (all shorts breed true).

Let Tt = a tall plant whose seeds give three talls to one short.

The symbol x indicates that two plants are crossed.

F^1, F^2, F^3, = the first, second, and third generations resulting from the cross.

TT x t t

Tt .... F^1

TT 2Tt t t .... F^2

TT TT 2Tt t t t t .... F^3

Having arrived at this practical result, Mendel went on to think out an explanation. He concluded that the differences in the plants must be due to

differences in the two reproductive or germ cells from which each had originated. A germ cell contained the factor for tallness or the factor for shortness, but never both. Thus he supposed that the tall plants of the original cross produced germs containing the tall factor, whilst the short plants produced germs containing the short factor. Hence the hybrid produced by crossing contained both factors, though, owing to tallness tending to conceal (or dominate) shortness, the hybrid was, in appearance, tall. However, when its sex-cells formed they could not contain both factors, and so half contained shortness and half contained tallness, *i.e.*, half the ovules contained shortness and half tallness, and the same was true for the pollen-grains. Hence when this pollen fertilised the ovules there were various possible combinations of the two factors, and the easiest way to grasp this is to imagine four typical ovules, two bearing tallness and two shortness. On an average :—

1 tall ovule	will	unite with	1 tall pollen	grain	giving	TT.
1 ,,	,,	,,	1 short	,,	,,	Tt.
1 short	,,	,,	1 ,,	,,	,,	tt.
1 ,,	,,	,,	1 tall	,,	,,	tT.

Hence our final result is four seeds having the constitution TT, tt, 2Tt, and, since tallness, if present, always shows, we shall have three tall and one short plant developing from these four seeds. This is what actually happens in the second hybrid generation, F^{2}. The short plant *must* breed true, *i.e.*, have nothing but short children, because it only contains short factors, but the tall plants will only breed true in the case of those which have only the tall factor (TT), *i.e.*, in one out of three. The other two talls are of mixed constitution (Tt)

and their children will be tall and short in proportion, 3 : 1. This, again, is what is actually found to happen in the third hybrid generation (F^3), and the agreement of the experimentally-observed results with the theoretical result in a strong argument for the truth of the theory.

Research has proved that many characters in plants and animals, including man, obey Mendel's law, *i.e.*, are inherited, or not, as indivisible units or wholes. Amongst these are many colour-characters in animals, horned and hornless condition in sheep and cattle, presence or absence of brown colour in the human eye, and presence or absence of certain human diseases, *e.g.*, (1) brachydactyly, a deformity in which the body is stunted and the fingers and toes seem to have only two instead of three joints apiece, (2) the disease known as night-blindness, in which the eye-retina is not sensitive to weak light, so that the victims are blind in the dusk or in moonlight, (3) presenile cataract, etc.

Another interesting point is that certain characters are only found in one sex, and also it may depend on sex as to whether a character is dominant or recessive. For instance, nearly all tortoise-shell cats are female ; nearly all colour-blind people are men, but a man hands on the defect only to his daughters, in whom it is recessive and therefore does not show, but they may hand it on to their sons, *i.e.*, it may show again in the grandsons of the original colour-blind man. Another disease which is inherited thus is hæmophilia, *i.e.*, the tendency to bleed easily. It will be remembered that the late Czarevitch suffered from this complaint.

This very short sketch of Mendel's work is enough,

I hope, to give some idea of the light which it shed on the problem of heredity and of the make-up of the individual. It has taught us to see each living man, woman, lower animal, and plant as built up, both physically and mentally, of definite ingredients or characters contributed by the two parents. And these characters can neither be created nor destroyed by the conditions or environment of life, though they will flourish in favourable conditions and be stunted by bad surroundings, but in either case they will be handed on in the germ-cells of the individual under consideration to his or her children, according to the Mendelian scheme. In fertilisation, with its many possible permutations and combinations of factors derived from the two parents, we get the origin of new individuals with as many possibilities of variation. If a new variation be harmful to its owner, Natural Selection (if allowed to act) will crush it out. If on the other hand the new variation be useful, Natural Selection will preserve it. Some scientists are content to ascribe all variations to the effect of crossing two individuals, but others feel that this is not enough to explain all variation—especially the production of distinctively new characters, *e.g.*, Professor J. A. Thomson points out that deeply saturating environmental influences may produce variations in the germ cells, and that there may also occur periodic re-organisation of the material of the nucleus which gives an opportunity for the origin of new variations. For a fuller discussion see Professor Thomson's *The System of Animate Nature*—a most fascinating and refreshing book. We can, at least, say that Mendel has shown us that if only we can isolate and distinguish the many characters which go to make up a living thing, and find out how those

characters affect one another, we shall be a long way on the road to the solution of the problems of heredity. The only way of doing this is by experimental breeding, *i.e.*, by mating individuals with outwardly definite characters and observing what the offspring of the union inherit—and this is a long, slow process needing much patience. It was just this steady power of patience and careful analysis rather than brilliant genius which Mendel possessed.

Practical Results.—Already very valuable practical results have sprung from Mendelism. Thus Agriculture has benefited greatly from the careful study of the characters of different varieties of wheat which have been carried out at Cambridge under Professor Biffen. It has been possible thus to breed a variety of wheat which combines the good points of English and foreign varieties whilst eliminating the bad points of both. The good point of the old English varieties was the heavy crops they gave ; their bad points were liability to be attacked by fungus and refusal to bake well owing to lack of proteid (gluten). Conversely, the foreign wheats rise well when baked, because they contain more gluten, but they give comparatively poor crops. However, by growing many varieties and observing the effect of crossing them, a variety has been created which is not attacked by fungus, has a high percentage of gluten, and gives a heavy crop. This clearly means a very practical gain to the farmer and to the prosperity of the country.

Other cereals, such as oats and barley, also root crops and pasture grasses, have been dealt with and improved, and it now remains to make all farmers realise that breed pays in seeds as much as it does in animals. A step in this direction was

taken in 1920, by the passing of the Seeds Act, which states that, with few exceptions, the sale of all farm seeds must be accompanied by a declaration of purity, germination, and genuineness based upon an official test. This policy of testing seeds and of improving breeds has been adopted for over twenty years by the well-known firm of Messrs. Gartons, Ltd., Warrington, Lancashire, and the heads of the firm are closely associated with the National Institution of Agricultural Botany at Cambridge. I would suggest that anyone who is interested in this fascinating side of Botany should, if he or she get the chance, visit Messrs. Gartons and learn something of their work at first hand.

Last, because not least, Mendelism holds out hopes of discovering facts about human heredity which will enable us to safeguard society, if we choose, from some at least of the numerous ills which at present beset it.

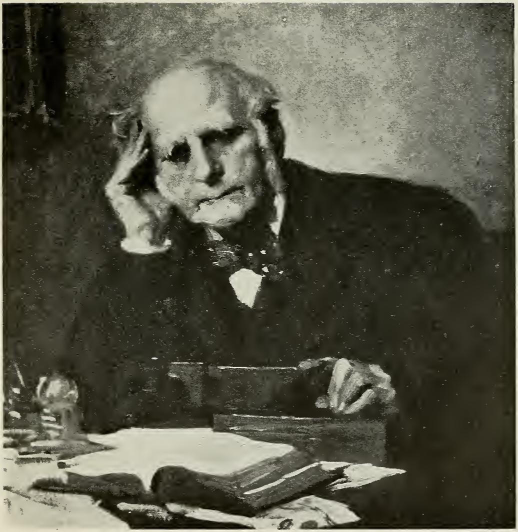
Mendel's scientific work practically ceased when he became Abbot of his monastery, probably in part because he became involved in quarrels with the government and in racial controversy, and his health failed. He died in 1884.

SIR FRANCIS GALTON

1822–1911

BORN in 1822, and so contemporary with Darwin, Wallace, Pasteur, Lister, and Mendel, Francis Galton holds his own amongst the intellectual giants of his time. He is chiefly famous for his work on human heredity, but his genius was no narrow one, and he did pioneer work also in meteorology, discovering for instance the system of atmospheric pressure and wind which we call the Anticyclone, and doing much work at the Meteorological Office in connection with equipping observatories with new instruments and methods of issuing weather charts to sea-ports, etc.

Galton came of a Birmingham family of Quakers, and a little study of its history shows how good an example it is of the handing on of ability from ancestors to descendants. Samuel Galton, the grandfather of Francis, was a successful business man, but with this he combined keen interest in science, belonging to a Scientific Society which, though small in numbers, included such famous men as Priestley, Dr. Erasmus Darwin, Watt, etc. The grandfather on the maternal side was Dr. Erasmus Darwin, the intellectually brilliant and many-sided physician whose grandson, Charles Darwin, may be said to have originated all modern biology, through his work on the *Origin of Species*. Thus Francis Galton and Charles Darwin were cousins. Francis Galton's father was a banker,



SIR FRANCIS GALTON, F.R.S.
1822-1911

but he also had a scientific turn of mind, being interested in astronomy and in wind and weather instruments and records. Further, he was a devotee of Shakespeare and of other writers too. He married Violetta Darwin, who lived to be 91, and her children, too, lived to remarkable ages. Their son acknowledges "the debt to my progenitors of a considerable taste for Science, for poetry and for statistics, also—a rather unusual power of enduring physical fatigue without harmful results."

There were seven children, of whom Francis was the youngest. At eight years old he was sent to school at Boulogne in order specially to learn French, but the school was run on wretched lines and all that Galton learned there he describes as a detested and limited patois, and after two years he came back to live with his parents at Leamington, and went to a small private school at Kenilworth for three years, where he was as happy under a man who understood and sympathised with boys as he had been unhappy in France. At fourteen he was sent to King Edward's School in Birmingham, but the type of education given in the school did not suit him, and he learned very little. He wanted to read good English literature and to study mathematics and science, instead of which he got "Grammar and the dry rudiments of Latin and Greek"—which he hated.

At sixteen he left school and his parents decided that he should be a doctor, so he was entered as a medical student of Birmingham General Hospital. This was long before the discoveries of Pasteur and Lister and of chloroform had revolutionised surgery, and this boy of sixteen had to accompany the surgeons at all operations and post mortems,

and help dress wounds in the casualty rooms at any hour of the day or night. The dreadful pain suffered by a patient operated on without anæsthetics made an operation a nightmare—a very different thing to what it is to-day, and Galton conceived the idea of making patients dead drunk before operating, as the result of seeing a drunken drayman have both legs amputated without suffering any pain. The idea was not put into practice—but it is interesting as a foreshadowing of the use of anæsthetics which was to come. So too was his decision to test the effects of all medicines in the pharmacopœia by taking doses of them, in alphabetical order. This, he says, " was an interesting experience but had obvious drawbacks," and he did not get beyond C, owing to the strong effects of croton oil.

There followed a year at King's College, London, which, he says, was mind-opening, and led him to the conclusion " that doctors had the fault, equally with parsons, of being much too positive," and that " There is still much lack of exact knowledge of what Nature can do without assistance from medicine and aided only by cheering influences, rest, suggestion and good nursing." This, again, is very up-to-date, in its foreshadowing of modern views on the effect of mind on body.

In 1840 Galton was seized with the desire to travel, and for six months wandered through Germany, Austria, Turkey, and Greece—an experience which strengthened his love of travel and widened his views of men and of civilisation. On his return he entered Trinity College, Cambridge, where he was struck both by the thoroughness of the work being done and by its narrowness, though he exonerates modern Cambridge from the latter

charge. Here he specialised in mathematics, and met and made friends of many men who later became famous. In his third year his health broke down, the result of too much, too irregular, and too varied work, and he had to miss a term. On his return he gave up reading for mathematical honours and reverted to medicine. However, his father's death in 1844 made him independent as regards money, and he gave up his medical work, though he says that he felt most grateful for the greater insight into Nature which it had given him.

He was now free to travel, and went to Egypt and the Soudan, where, after wandering up the Nile, he reached "that then sink of iniquity, Khartum," where resided a group of villainous European slave-dealers, whose acquaintance Galton made, with the comment that "the experience was acceptable, for one wants to know the very worst of everything as well as the very best." Returning *via* Syria and Palestine, he settled for a time at Leamington, living from 1846–50 the life of the ordinary English country gentleman, shooting, hunting—but also reading a good deal, and doing one bit of scientific work in connection with telegraphy, which was then a new discovery.

This kind of life, however, soon ended, for the call of the wild again came to him, a call stronger in those days than now, for great areas of the world were still unexplored mysteries, represented only by blanks on the map. Thus the interiors of Africa, Australia, and Central Asia were largely unknown ground, and so were the Polar regions. Galton was filled with the desire to explore, and a cousin suggested that he should consult the Royal Geographical Society as to the regions where exploration would be most valuable. The Society gave him

careful advice and introductions to various useful people, and he left England in 1850 for South Africa On arrival at Cape Town he had to alter his plans, owing to difficulties with the Boers and the Government, so he sailed up the coast to Walfish Bay and then struck inland towards Lake Ngami, a journey full of difficulties, through a country occupied by three different races, viz., Yellow Hottentots, Bantus, and negroes, as well as by smaller tribes of Bushmen, etc. After leaving the low coastal belt, the route lay over a dry sandy plateau, 6,000 ft. above sea-level, where thorn-bushes were a serious obstacle and water had to be dug for almost daily. The caravan consisted of ten Europeans and about eighteen natives, with two wagons, ninety-four oxen, cows and calves, and twenty-four sheep. The party relied for food on the cattle and occasional game. They travelled right across Damaraland and beyond it, and soon they saw something of the atrocities of savage life—savage tribal warfare, murders, the killing of the sick by their relations, and mutilation for small offences were rife, and there were signs of ill-will to themselves. As Galton says, he did not realise the strain of anxiety under which he lived till he returned to Walfish Bay in December, 1851, after travelling over 2,000 miles. In recognition of the work done on this journey, the Geographical Society, in 1854, awarded him one of their two annual Gold Medals, and this gave him an established position in the scientific world. In 1856 he was elected a Fellow of the Royal Society—so winning the blue ribbon of the scientist.

On his return to England he married, in 1853, Miss Butler, daughter of the Dean of Peterborough, whose family was remarkably gifted intellectually.

All the four sons were distinguished scholars and their children showed exceptional ability. As Galton says, the Butler family well deserve study as an instance of hereditary gifts, and then he speaks of "the far greater importance of being married into a family that is good in character, in health, and in ability, than into one that is either very wealthy or very noble, but lacks these primary qualifications. . . . Moreover, the interests of the unborn should be taken far more seriously into account than they now are. Enough is already known of the laws of heredity to make it certain that the marriage of one class of persons will lead on the whole to good results, and that of another class to evil ones, however doubtful the result may be in particular cases."

Galton's next work was to write a small book called the *Art of Travel,* intended to help explorers in their journeys, and, when the Crimean War began, the ignorance of the soldiers in matters of camp-life spurred him to offer to give lectures at Aldershot on this subject.

Galton was now made a member of the Managing Committee of Kew Observatory, which had a great reputation for the exactness of its observations and for the standardisation of the instruments of all other magnetic observatories, both at home and abroad, as well as of thermometers and other meteorological instruments. Here Galton took up the standardisation of sextants and other angular instruments, which at that time were very unsatisfactory in construction, and he succeeded in getting the cheaper sextants much improved. He also invented an apparatus for quick and accurate testing of thermometers which proved of considerable monetary value to the Observatory.

Becoming interested in weather observations, he collected data from many observatories, lighthouses, and ships, and so, in 1862, discovered the *Anticyclone*, now so familiar to us in our school geographies as the exact opposite of the cyclone. The anticyclone is a system of winds constituted by a down-rush of air which then flows outwards from its centre in a spiral, clockwise in the Northern Hemisphere. This state of affairs is accompanied by a high barometer, clear sky, and either very high or very low temperatures, according as it occurs in summer or in winter.

In 1868 Galton was elected a member of a Meterological Committee formed in order to give warning of storms to seaports and to maintain a few standard observatories with self-recording instruments, and for thirty-four years he took an active share in the work. On his resignation in 1901, the chairman wrote: " . . . The Council feel that the same high order of intelligence and inventive faculty has characterised your scientific work in Meteorology that has been so conspicuous in many other directions . . . " The work of the Observatory grew so rapidly that it was felt that the institution needed to be re-modelled on a larger scale, and so it was converted into the National Physical Laboratory in 1901.

And now we can turn to the work for which this man of many-sided genius is chiefly famous, that on *human heredity*. Like so much of the scientific work of that day, it received a great stimulus from Darwin. Galton says that the publication of Darwin's *Origin of Species* in 1859 made a marked epoch in his own mental development, " as it did in that of human thought generally. Its effect was to demolish a multitude of dogmatic barriers by a

single stroke, and to arouse a spirit of rebellion against all ancient authorities whose positive and unauthenticated statements were contradicted by modern Science." His description of the reception of Darwin's book is interesting, somewhat depressing, and I think serves as a warning to most of us in our dealings with new ideas, since the attitude of mind here depicted is still pretty rife :—" I doubt, however, whether any instance has occurred in which the perversity of the educated classes in misunderstanding what they attempted to discuss was more painfully conspicuous. The meaning of the simple phrase, 'Natural Selection,' was distorted in curiously ingenious ways, and Darwinism was attacked, both in the press and pulpit, by persons who were manifestly ignorant of what they talked about. This is a striking instance of the obstructions through which new ideas have to force their way. Plain facts are apprehended in a moment, but the introduction of a new Idea is quite another matter, for it requires an alteration in the attitude and balance of the mind which may be a very repugnant and even painful process."

As we have said, Darwin's work encouraged Galton to further study of human heredity and the possibilities of improving human beings. Opinions on heredity at this time were very contradictory and uncertain. Many people thought that the lower animals inherited their bodily, and some mental, characteristics, but they denied that this was true of Man. Even the word " heredity " was strange and considered a fanciful new invention. Now Galton had been greatly struck by many cases of heredity amongst the men at Cambridge University, and in 1865 he wrote two papers for *Macmillan's Magazine* on *Hereditary Talent and*

Character, which he says contain the germ of many of his later books, viz., *Hereditary Genius*, 1869; *English Men of Science*, 1874; *Human Faculty*, 1883; *Natural Inheritance*, 1889; and his writings on Eugenics.

Darwin, after reading *Hereditary Genius*, wrote to the author: " . . . I must exhale myself, else something will go wrong in my inside. I do not think I ever in all my life read anything more interesting and original. . . . You have made a convert of an opponent in one sense, for I have always maintained that, excepting fools, men did not differ much in intellect, only in zeal and hard work; and I still think this is an eminently important difference . . . ." Commenting on this, Galton says that character, including the aptitude for work, is heritable, like every other faculty.

The second book of this group, viz., *English Men of Science*, was based on investigations into the histories of Fellows of the Royal Society, and its aim was to show that aptitude for Science was largely inborn and not acquired, and was therefore hereditary. Incidentally Galton concludes that men are more capable of scientific research than are women, since the latter are biased by the emotions and more inclined to obey authority. If so, recognition of the fact may save some of us from pitfalls.

Now Galton turned to a question which had long interested him, viz., the relative powers of Heredity and Environment in shaping the individual, and he hit on the ingenious idea that the history of twins might help to solve the problem. He divided twins into two groups:—(1) those who were closely alike in youth and were afterwards parted, and (2) those who were unlike in youth but were brought up

together. The conclusion of his observations on these is that similarity persists in spite of different environment, whilst differences also persist, in spite of similar environment, *i.e.*, Nature is far stranger than Nurture. The account of this work forms an interesting chapter in his book, *Inquiries into Human Faculty*, published in *Everyman's Library*. Following this, Galton flung himself into mathematical and statistical study of heredity, the details of which are too complex to discuss here; but he felt that he must collect quantities of exact measurements of every faculty of body and mind which *could* be measured, to form a base for his conclusions, and in the course of doing so he made several and useful and interesting discoveries of which I will mention two. The first was the *Galton Whistle*, a whistle the pitch of whose note can be varied, so as to determine the highest note which can be heard. This varies in different people, at different ages, and in different species of animals. Thus a cat can often hear a note which is too high to be heard by a human being, whilst a bat's scream is too high to be heard by some people. The other discoverey was a method of identifying people from their finger-prints. This was adopted by the Home Office for the identification of criminals, etc., at Scotland Yard.

His study of heredity led on to his last and most important work, that on Eugenics, or Race Improvement in human beings. The idea of this as a practical possibility had long lain in his mind, but for many years the public was so lacking in knowledge of the science of biology and of the facts of heredity that it was quite impossible for him to lay his ideas before that public with any hope that they would be understood. At last, however, he felt

that there had come into existence at least a small number of thinking men and women who would give his ideas a fair hearing, and in 1884 he coined the word "Eugenics" for the new Science of which he is the modern founder. I say "modern" because the idea of the improvement of the human race is found far back in antiquity, *e.g.*, in the writings of Plato, and the word Eugenics is derived from the Greek *eugenes*, meaning "well-born"—not in our modern snobbish social sense, but in the true sense of descent from parents of sound qualities of body and mind. In spite of Galton's long waiting for the education of public opinion, he did not escape misunderstanding nor stupid criticism, *e.g.*, people said that he advocated breeding human beings in the same way as one breeds animals, and accused him of a disgustingly material view of love and marriage, whereas the truth was that he had urged the country to prevent people afflicted with lunacy, feeble-mindedness, habitual criminality, etc., from having children, on the ground that these defects were inherited by the children, and so gave rise to a type of humanity which was a constant danger to and drag on the worthier types. He says:* "I cannot doubt that our democracy will ultimately refuse consent to that liberty of propagating children which is now allowed to the undesirable classes, but the populace has yet to be taught the true state of these things. A democracy cannot endure unless it be composed of able citizens; therefore it must in self-defence withstand the free introduction of degenerate stock. What I desire is that the importance of Eugenic marriages should be reckoned at its just value, neither too high nor too low, and that Eugenics should form one of the

* "Memories of My Life," 1909.

many considerations by which marriages are promoted or hindered, as they are by social position, adequate fortune, and similarity of creed. I can believe hereafter it will be felt as derogatory for a person of exceptionally good stock to marry into an inferior one as it is for a person of high Austrian rank to marry one who has not sixteen heraldic quarterings. I also hope that social recognition of an appropriate kind will be given to healthy, capable, and large families, and that social influence will be exerted towards the encouragement of Eugenic marriages."

I think that anyone who honestly looks facts in the face to-day will be forced to see that, as a nation, we stand badly in need of practical application of Eugenics. The increase in population is far too largely amongst the physically or mentally unfit. And too much of our charity and of our legislation succeeds only in increasing the undesirable types at the expense of the desirable.

In 1904 Galton founded a Fellowship at London University for research in Eugenics, which is defined in the Statutes as "The Study of Agencies under Social Control, which may improve or impair the racial qualities of future generations either physically or mentally;" and in 1907 a Eugenics Laboratory under Professor Karl Pearson came into being in the University and was endowed by Galton. The Laboratory has issued a series of most interesting reports and memoirs of its work (at 1/- each, published by Dulau & Co.). Further, in 1908, the Eugenics Education Society was founded, to spread knowledge of Eugenics in a more popular form. Its President is Major Leonard Darwin, and the Vice-Presidents and Members of the Council include men distinguished in Science, Sociology,

Medicine, and in Theology. It is a hopeful sign of life in the Church that Dean Inge should be on the Executive Committee of this Society, and one hopes that soon the Church in general will see that Eugenics is an ally and not an enemy, for, as Canon Lyttleton says, the ground principle of Eugenics is a deepened sense of the value of human life—and this was one of the greatest truths taught by Christ.

Anyone who cares to find out more about this very interesting and important Science should send to the offices of the Eugenics Education Society, 11, Lincoln's Inn Fields, W.C. 2., for a list of the pamphlets and books which they publish. These include Galton's *Essays in Eugenics* (1/6), the quarterly *Eugenics Review* (2/6), and a number of excellent papers by specialists on social questions—and which of us can ignore these questions to-day? Another useful little book is Schuster's *Eugenics* (1/-, Collins).

In 1911 Galton died and was buried at Claverdon, near Warwick.

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